AFFORDING STRIKING PROOF OF THE EFFICACY OF ANDERSON SHELTERS:

ALMOST MIRACULOUS ESCAPES IN MIDLAND AND SOUTH OF ENGLAND HOMES.

AN ANDERSON SHELTER, CORRECTLY COVERED WITH EARTH (FROM WHICH CABBAGES SPROUT), UNHARMED DESPITE SURROUNDING BOMB DAMAGE. *Wide World.*

DAMAGED HOUSES, WITH AN UNTOUCHED ANDERSON SHELTER IN THE FOREGROUND, WHOSE OCCUPANTS FOUND COMPLETE SAFETY. *(Planet.)*

INTACT AMONG THE DÉBRIS CAUSED BY GERMAN BOMBS: AN ANDERSON SHELTER IN A S.-W. LONDON SUBURB. *(Planet.)*

TWO ANDERSON SHELTERS IN THE SAME DISTRICT AS THAT SHOWN IN THE PHOTOGRAPH ON THE LEFT, ALSO INTACT. *(Planet.)*

THE violent and very expensive raids by the *Luftwaffe* in the week ending August 17 provided a most reassuring demonstration of the efficacy of the Anderson shelter, when it has been properly covered with earth and the entrance adequately screened. Both at Croydon and in the Midlands its value was proved. When a bomb dropped in the middle of a triangle formed of three Anderson shelters in a Midlands town the occupants of all escaped unhurt. Seven people taking cover in a home-made shelter, however, were killed. Seven persons sheltering in an Anderson shelter in another Midlands area were unharmed by a bomb which exploded immediately outside it. When sixteen Nazi bombers were caught at Tilbury (Essex) between the A.-A. barrage and "Spitfires," they scattered and fled to sea with a vicious pursuit encouraging them. Six of their bombs fell on a housing estate. Four exploded harmlessly on grass verges, and two blew out the sides of a council house, but the occupants were in their Anderson shelter, less than ten yards away, and were unhurt. One man in South London, with his wife and two children, who had been evacuated from Folkestone, said that they were in an Anderson shelter during the raid on August 18 when five bombs fell within a distance of 100 yards. "Our little shelter trembled," he said, "but we suffered no shock and no damage, though our windows were broken." On the other hand, people in an Anderson shelter in the South-Western suburbs were injured by bomb splinters penetrating the back of the shelter, which was not completely covered with earth.

A LARGE BOMB-CRATER BEHIND A ROW OF DAMAGED HOUSES AFTER THE CROYDON RAID: THE SHELTERS WERE UNAFFECTED. *(Keystone.)*

A CRATER, 25 FT. DEEP, OUTSIDE A DAMAGED HOUSE IN CROYDON. ALL THE OCCUPANTS OF THE SHELTERS ESCAPED INJURY. *(Topical.)*

HARDLY THE "COWERING" LONDONERS OF DR. GOEBBELS' IMAGINATION: A CHEERFUL NORTHFLEET FAMILY SITTING BY THEIR SHELTER AFTER A RAID. *(Fox.)*

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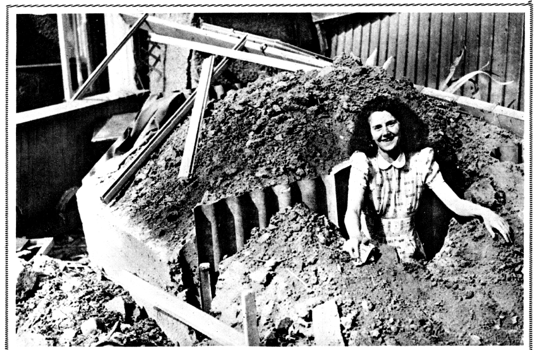

GIVING THE LIE TO GOEBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. *(Planet.)*

15 Sept 1940: Anderson shelter occupants survived air raid, Ransome Way, Liverpool

Anderson shelter occupants survive air raid destruction at Purfleet

17 June 1944: Anderson shelter absorbs blast from V1 at Elsenham Rd, East End, London

Family survive without injury in wrecked Anderson shelter (note earth blown off) during London Blitz in 1940. Damage to the shelter absorbed the blast energy.

28 Jan 1945: Priory Road, East Ham

27 April 1944: Anderson shelter occupants survive at Forest Drive, East End, London

10 July 1944: Anderson shelter occupants survive air raid at Harcourt Avenue, East End, London

17 July 1944: Anderson shelter occupants survive at Tennyson Ave, Plashet Grove

And They Came Out of It Alive...

The edge of this bomb crater, 30ft. deep, in a household garden near London, is only 4ft. from the Anderson shelter. But the two people in the shelter during London's six-hour raid—Mrs. Clark and Miss Clark—were unhurt. You see Miss Clark in the picture examining the damage to the structure.

Daily Mirror
28 Aug 1940

UK NATIONAL ARCHIVES: ES 5/2

ANDERSON SHELTER TESTS AGAINST 25 KT NUCLEAR NEAR SURFACE BURST (2.7 METRES DEPTH IN SHIP)

AWRE-T1/54, 27 Aug. 1954

SECRET—GUARD

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

(formerly of Ministry of Supply)

SCIENTIFIC DATA OBTAINED AT OPERATION HURRICANE

(Monte Bello Islands, Australia—October, 1952)

$$p = \frac{130 \times 10^9}{R^3} + \frac{7 \cdot 7 \times 10^6}{R^2} + \frac{13 \cdot 5 \times 10^3}{R}$$

p is the maximum excess pressure in p.s.i. and R is the distance in feet

Fig. 12.1, Andersons at 1380 ft range from bomb ship shown in the photo, moored 400 yards off shore.

Left: Fig. 12.3, Andersons at 1800 ft after burst. Right: Fig. 12.4, Andersons protected by blast walls at 2760 ft.

12.1. *Blast Damage to Anderson Shelters*

At 1,380 feet, Fig. 12.1, parts of the main structure of the shelters facing towards and sideways to the explosion were blown in but the main structure of the one facing away from the explosion was intact, and would have given full protection. At 1,530 feet, Fig. 12.2, the front sheets of the shelter facing the explosion were blown into the shelter but otherwise the main structures were more or less undamaged, as were those at 1,800 feet, Fig. 12.3.

At 2,760 feet, Fig. 12.4, some of the sandbags covering the shelters were displaced and the blast walls were distorted whilst at 3,390 feet, Fig. 12.5, the effect was quite small. At these distances, the shelters were not in direct view of the explosion owing to intervening sandhills.

13. The Penetration of the Gamma Flash

13.1. *Experiments on the Protection from the Gamma Flash afforded by Slit Trenches*

13.1.1. The experiments described in this section show that slit trenches provide a considerable measure of protection from the gamma flash. From the point of view of Service and Civil Defence authorities this is one of the most important results of the trial.

13.1.2. Rectangular slit trenches 6 ft. by 2 ft. in plan and 6 ft. deep were placed at 733, 943 and 1,300 yards from the bomb and circular fox holes 2 ft. in radius and 6 ft. deep were placed at 943 and 1,300 yards.

The doses received from the flash were measured with film badges and quartz-fibre dosimeters in order to determine the variation of protection with distance, with depth and with orientation of the trench and the relative protection afforded by open and covered trenches.

In general, the slit trenches were placed broadside-on to the target vessel but at 1,300 yards one trench was placed end-on. Two trenches, one at 733 and one at 943 yards were covered with the equivalent of 11 inches of sand.

Table 13.1

Variation of Gamma Flash Dose on Vertical Axis of Trench

Type of trench	Rectangular broadside-on open			Rectangular end-on open	Circular open		Rectangular broadside-on covered	
Distance (yards) ...	1,300	943	733	1,300	1,300	943	943	733
Surface dose (Roentgens)	300	3,000	14,000	300	300	3,000	3,000	14,000
Depth below ground level (inches)								
6 ...	150	1,000	—	230	214	1,200	(75)	—
12 ...	75	430	—	150	120	545	47·6	—
24 ...	33·3	150	584	60	54·5	188	25	(140)
36 ...	23	70	216	31·6	30	86	13	(56)
48 ...	(20)	43	100	20	17·7	48·5	7·7	(31)
60 ...	—	(37·5)	61	13·6	10·7	(33·3)	5	(23)
72 ...	—	—	(46·7)	(8·6)	7	—	(3·5)	—

Entries in brackets are extrapolations or estimates.

It cannot be too strongly emphasised that it is most important, from the point of view of reducing casualties as a whole, for everyone in an area under attack to make use of any shelter that is available. Recent research has shown that there would be less fatal casualties if everyone were in relatively poor shelter than if half the population were in shelter twice as good and the other half remained in the open.

THE RISK OF BECOMING A CASUALTY

(Basic Methods of Protection Against High Explosive Missiles - Manual of Basic Training, Civil Defence, vol. 2, Pamphlet 5, H.M.S.O., 1951)

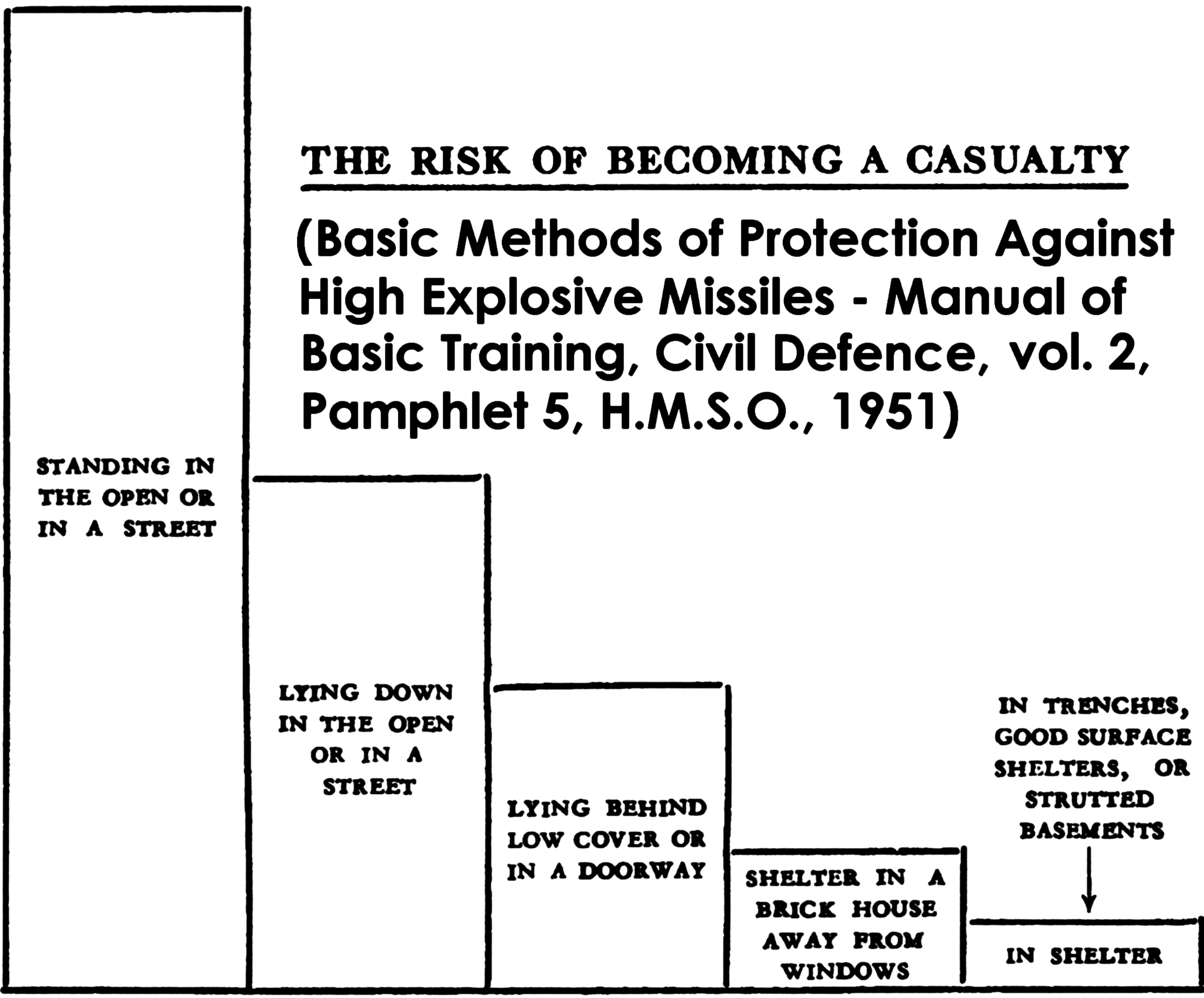

Fig 3 Variation of mortality index with size of incident for explosives (from table E)

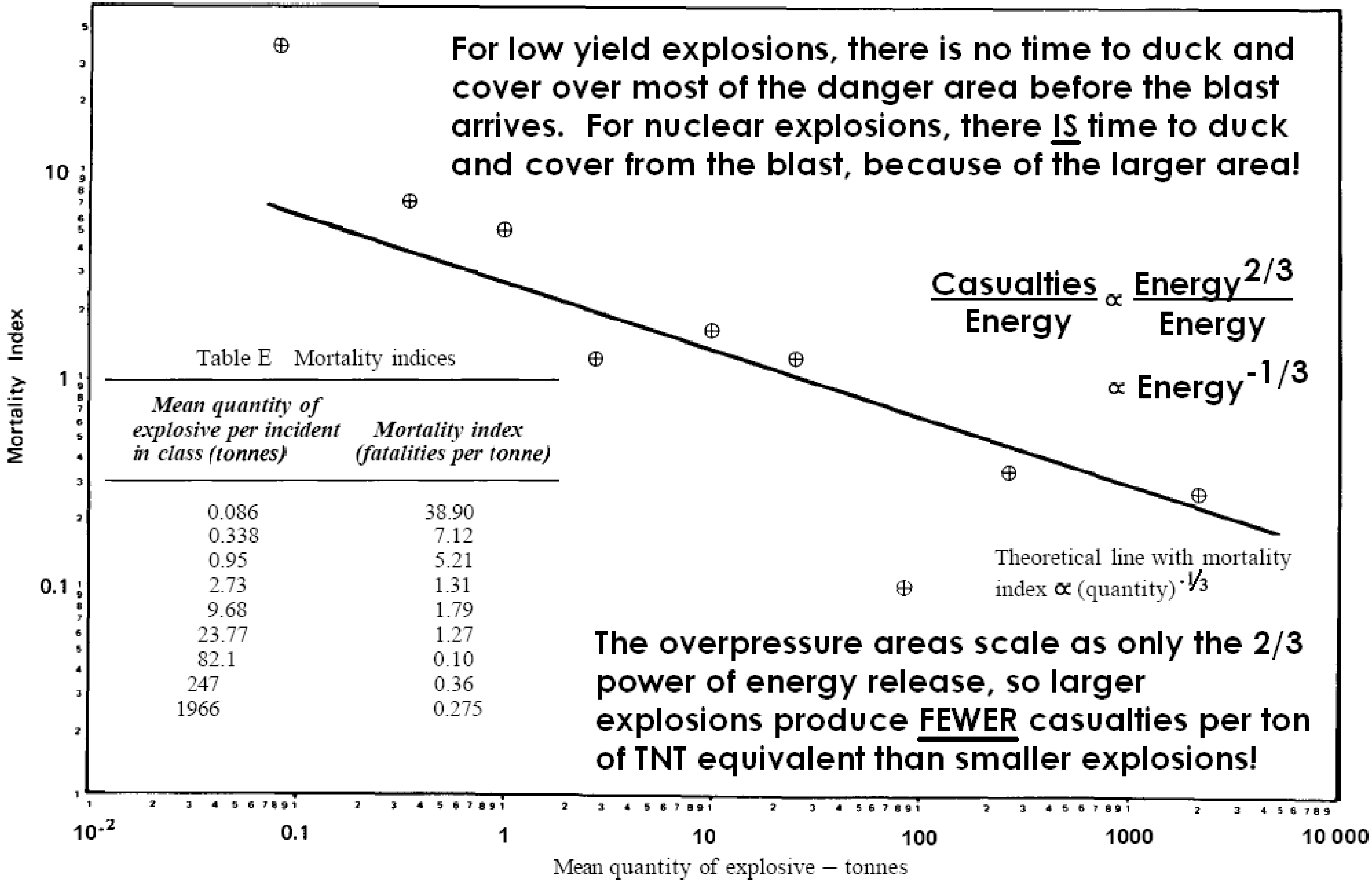

Table E Mortality indices

Mean quantity of explosive per incident in class (tonnes)	*Mortality index (fatalities per tonne)*
0.086	38.90
0.338	7.12
0.95	5.21
2.73	1.31
9.68	1.79
23.77	1.27
82.1	0.10
247	0.36
1966	0.275

Health & Safety Commission

Advisory Committee on Major Hazards

SECOND REPORT

HER MAJESTY'S STATIONERY OFFICE *1979*

AFFORDING STRIKING PROOF OF THE EFFICACY OF ANDERSON SHELTERS:

ALMOST MIRACULOUS ESCAPES IN MIDLAND AND SOUTH OF ENGLAND HOMES.

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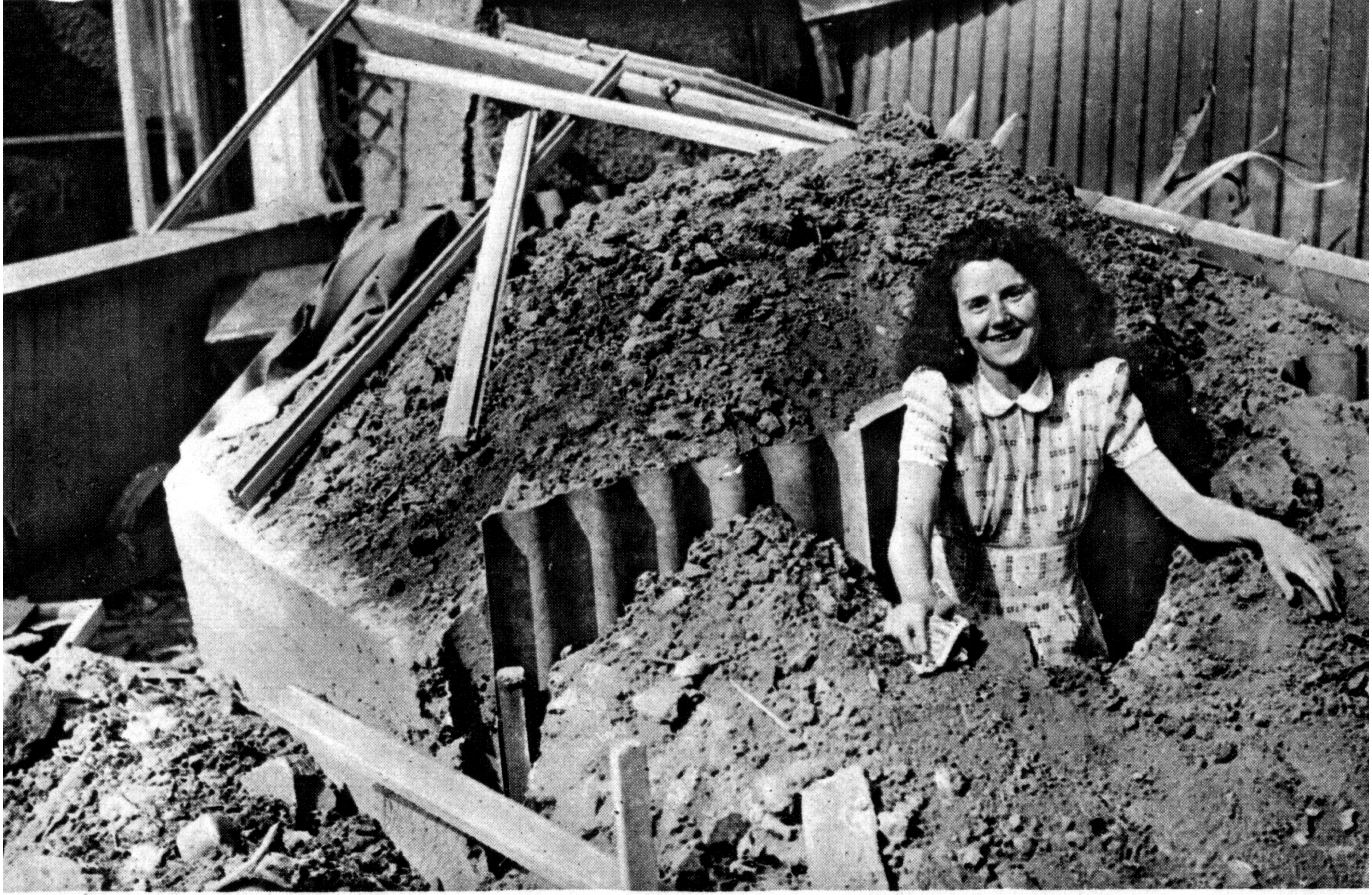

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HOME OFFICE

AIR RAID PRECAUTIONS

DIRECTIONS
FOR THE ERECTION AND SINKING OF THE GALVANISED CORRUGATED STEEL SHELTER

(ANDERSON SHELTER)

February 1939

London family who survived in Anderson shelter during Blitz, when the shelter absorbed the blast (earth was blown off) in 1940

A.R.P. (O) 10

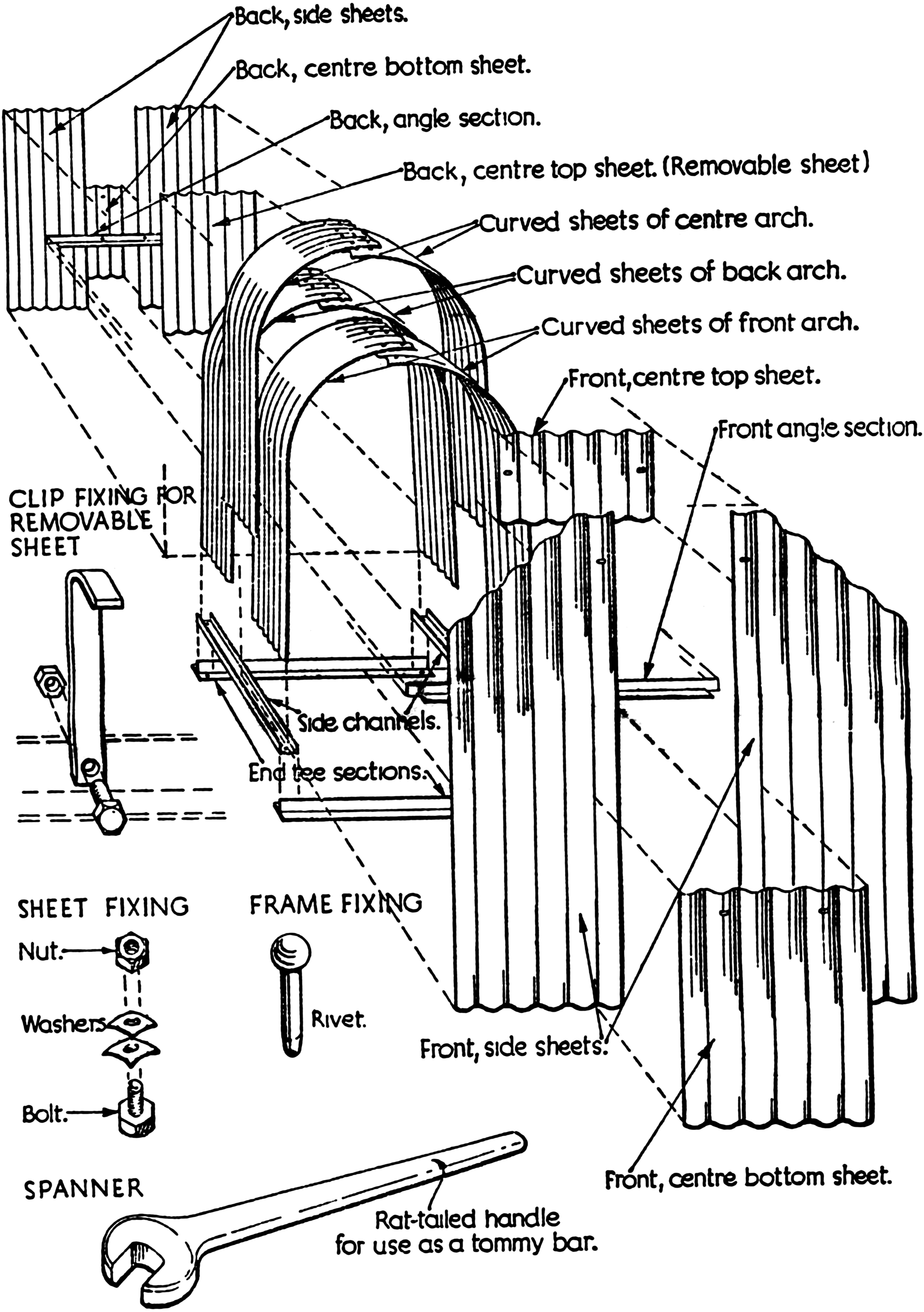


FIG. 3.—THE INDIVIDUAL PARTS.

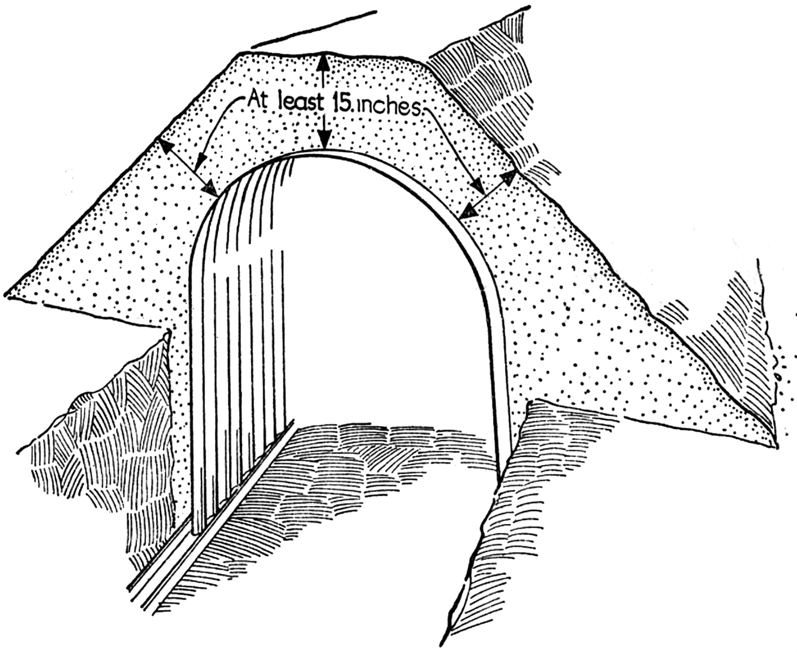


FIG. 4.—STAGE 12. COVERING THE SHELTER WITH EARTH.

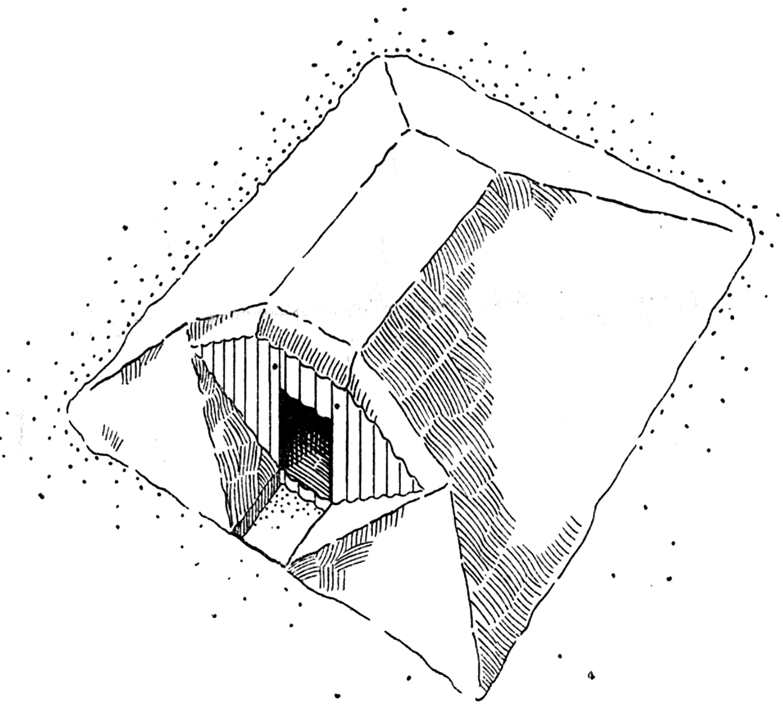
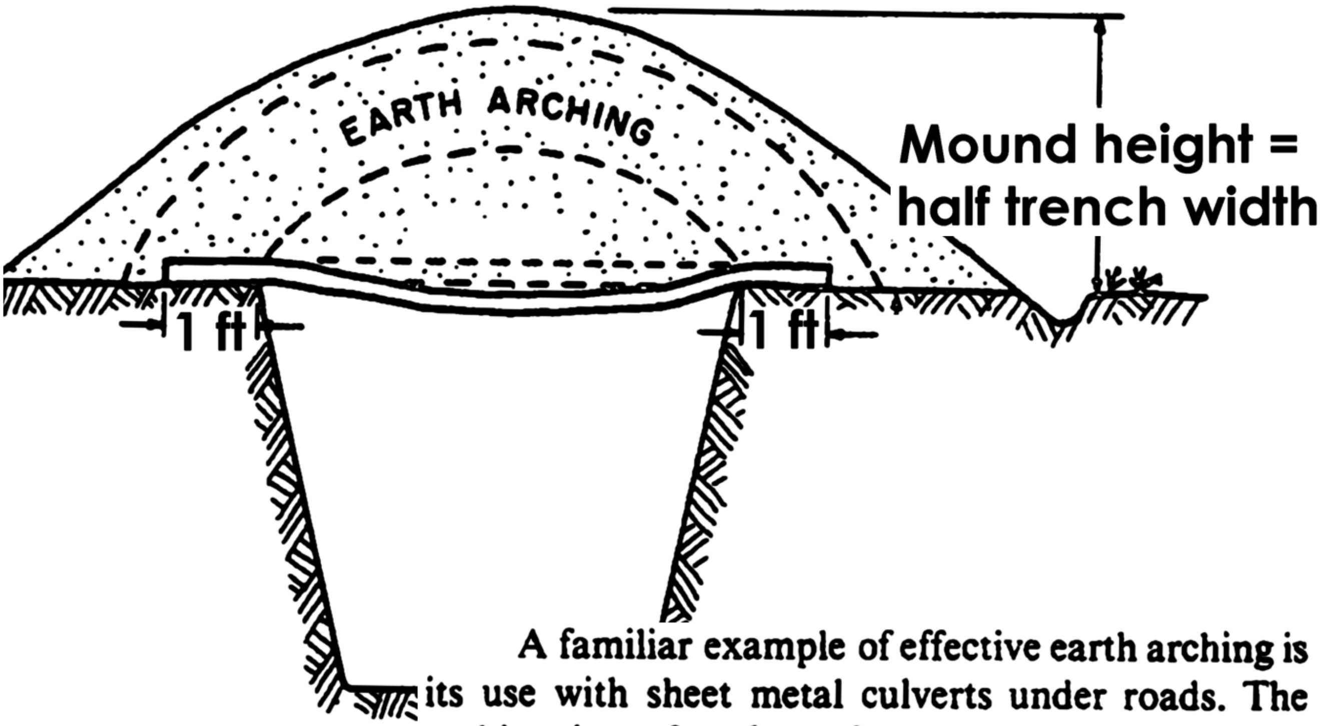


FIG. 4.—STAGE 13. THE SHELTER COMPLETE WITH EARTH COVER.

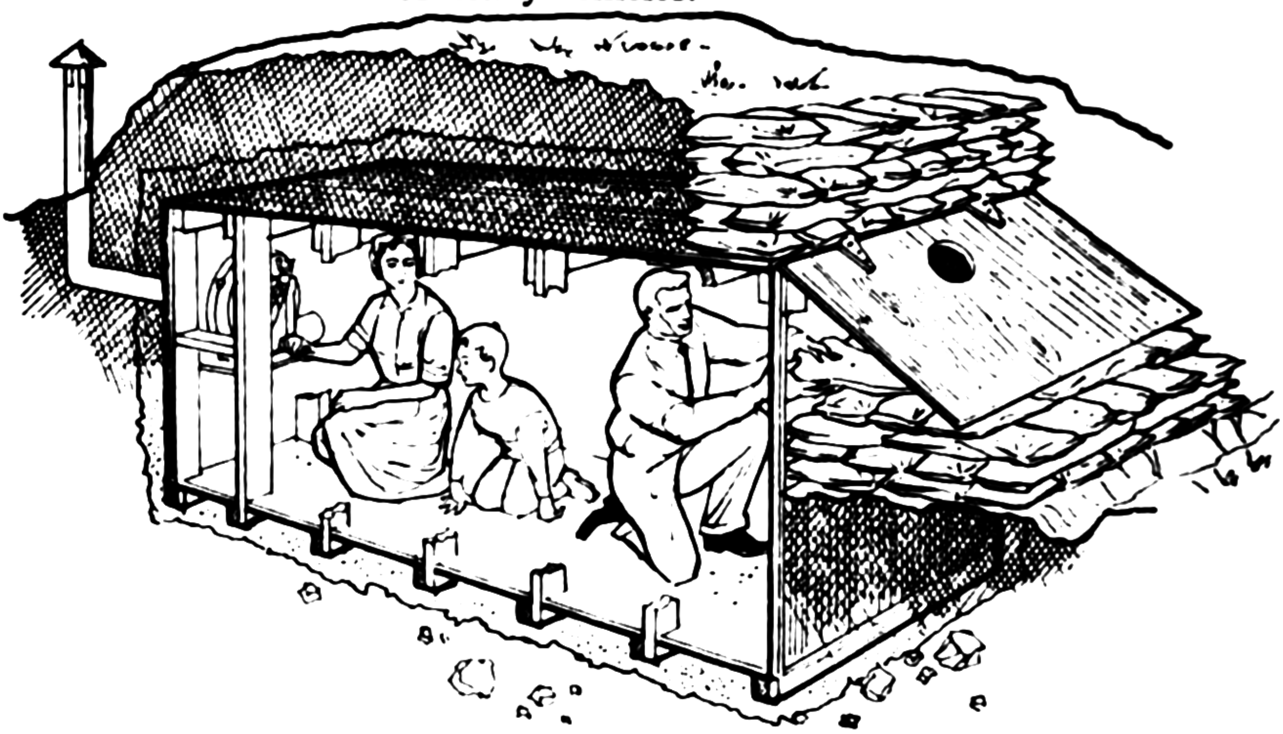
Anderson shelter survives hit: Norwich 27 April 1942

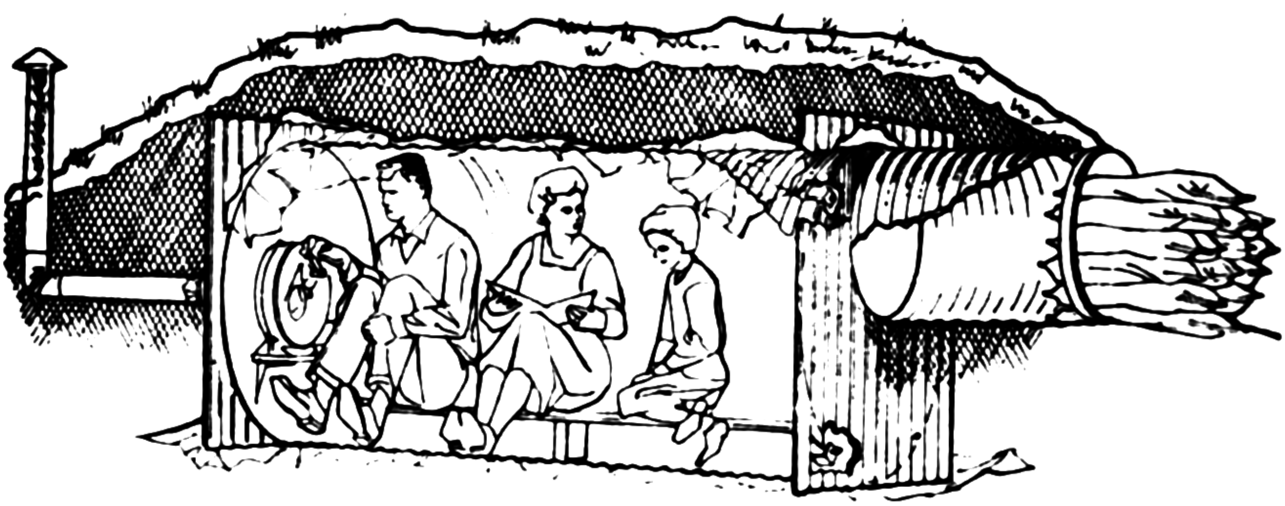
EARTH ARCHING USED TO STRENGTHEN SHELTERS

ORNL-5037



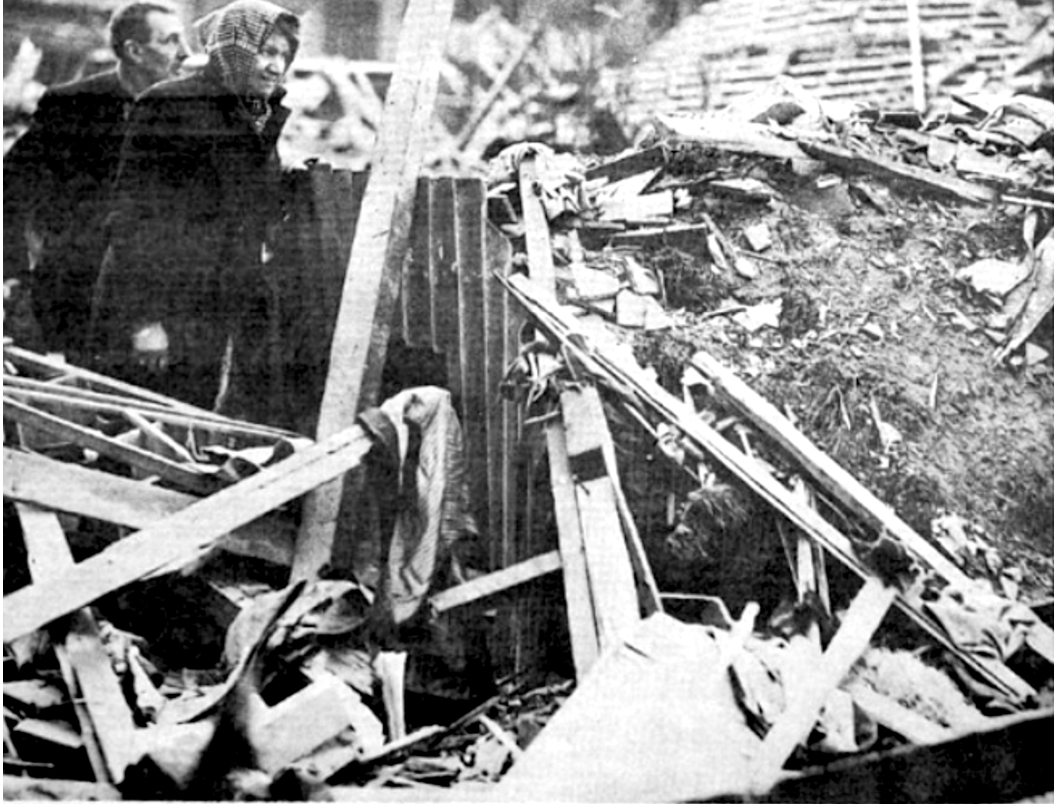
A familiar example of effective earth arching is its use with sheet metal culverts under roads. The arching in a few feet of earth over a thin-walled culvert prevents it from being crushed by the weight of heavy vehicles.





Anderson shelter survives, Croydon, October 1940

29 July 1944: St Johns Rd, London, Mr and Mrs Dermott and Sgt Harrington



Proof that the Anderson garden shelter could withstand a house collapsing on it can be seen in this picture. Mr. and Mrs. Clague bless their insistence on 'going to ground' when their homes and those of their neighbours were reduced to rubble.

18 June 1941

Anderson shelter survives at Latham Street, Poplar, London, 1941:

THE EFFECTS OF THE ATOMIC BOMBS AT HIROSHIMA AND NAGASAKI

REPORT OF THE BRITISH MISSION TO JAPAN

PUBLISHED
FOR THE HOME OFFICE AND THE AIR MINISTRY BY
HIS MAJESTY'S STATIONERY OFFICE
LONDON
1946

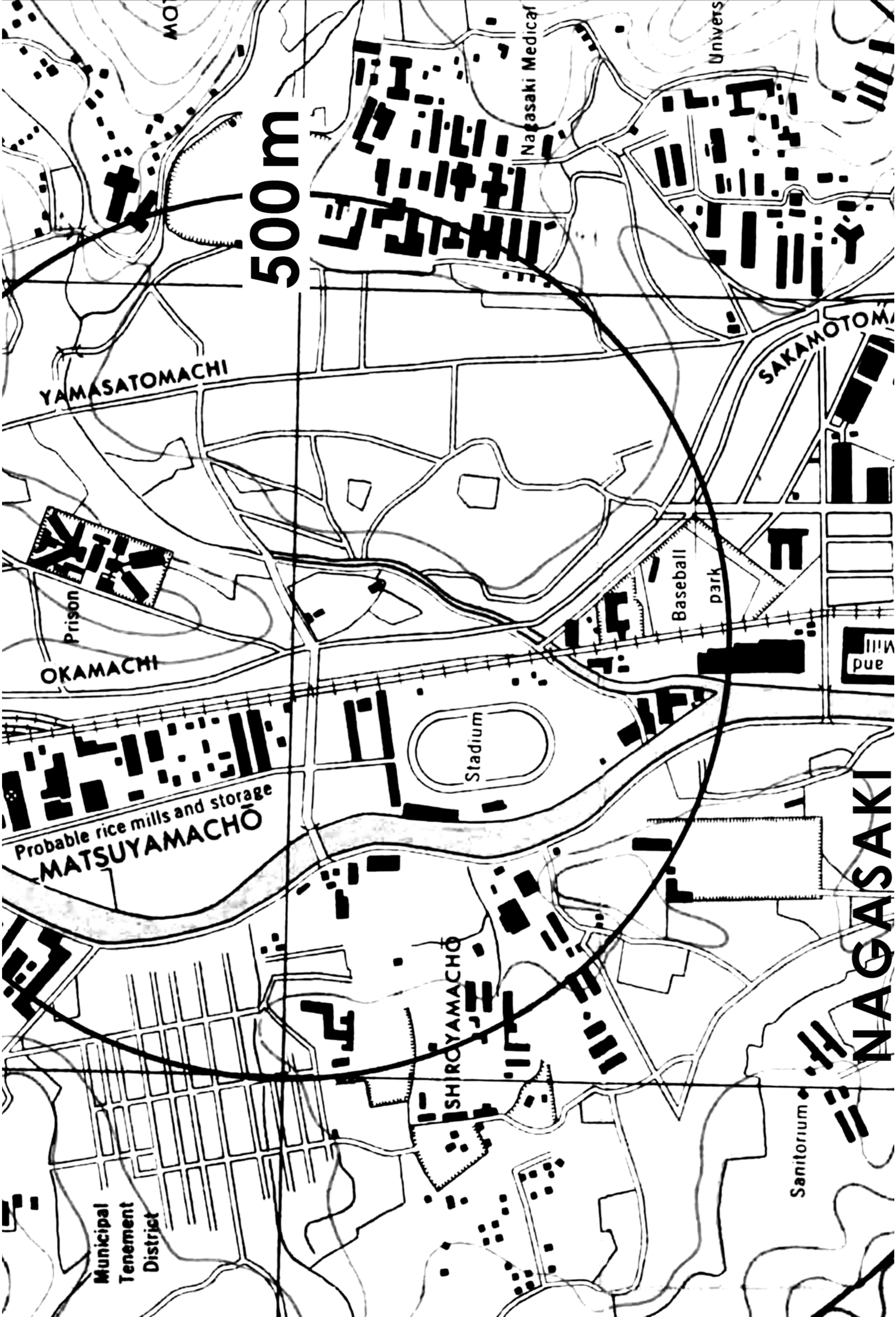
40. The provision of air raid shelters throughout Japan was much below European standards. Those along the verges of the wider streets in Hiroshima were comparatively well constructed : they were semi-sunk, about 20 ft. long, had wooden frames, and 1 ft. 6 ins. to 2 ft. of earth cover. One is shown in photograph 17. Exploding so high above them, the bomb damaged none of these shelters.

41. In Nagasaki there were no communal shelters except small caves dug in the hillsides. Here most householders had made their own backyard shelters, usually slit trenches or bolt holes covered with a foot or so of earth carried on rough poles and bamboos. These crude shelters, one of which is shown in photograph 18, nevertheless had considerable mass and flexibility, qualities which are valuable in giving protection from blast. Most of these shelters had their roofs forced in immediately below the explosion ; but the proportion so damaged had fallen to 50 per cent. at 300 yards from the centre of damage, and to zero at about $\frac{1}{2}$ mile.

42. These observations show that the standard British shelters would have performed well against a bomb of the same power exploded at such a height. Anderson shelters, properly erected and covered, would have given protection. Brick or concrete surface shelters with adequate reinforcement would have remained safe from collapse. The Morrison shelter is designed only to protect its occupants from the debris load of a house, and this it would have done. Deep shelters such as the refuge provided by the London Underground would have given complete protection.

Photo No. 17. HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage, which is to the right. In common with similar but fully sunk shelters, none appeared to have been structurally damaged by the blast. Exposed woodwork was liable to " flashburn." Internal blast probably threw the occupants about, and gamma rays may have caused casualties.

Photo No. 18. NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage, which is to the right. There was a large number of such shelters, but whereas nearly all those as close as this one had their roofs forced in, only half were damaged at 300 yds., and practically none at half a mile from the centre of damage.



500 m
Nagasaki Medical
YAMASATOMACHI
Prison
OKAMACHI
Baseball
park
Stadium
Probable rice mills and storage
MATSUYAMACHŌ
SHIROYAMACHO
Sanitorium
Municipal
Tenement
District
NAGASAKI

15
1
2000
12
1000
GROUND ZERO
17
16
20
18
22

Tunnel shelters in hillside, very close to ground zero in Nagasaki, protected the occupants from blast, thermal radiation, and immediate nuclear radiation.

3rd October, 1963. ~~RESTRICTED~~ For Pro

HOME OFFICE

SCIENTIFIC ADVISER'S BRANCH

CD/SA 116

RESEARCH ON BLAST EFFECTS IN TUNNELS

With Special Reference to the Use of London Tubes as Shelter

by F. H. Pavry

Summary and Conclusions

The use of the London tube railways as shelter from nuclear weapons raises many problems, and considerable discussion of some aspects has taken place from time to time. But - until the results of the research here described were available - no one was able to say with any certainty whether the tubes would provide relatively safe shelter or not.

The more recent research here described showed for the first time that a person sheltering in a tube would be exposed to a blast pressure only about $\frac{1}{3}$ as great as he would be exposed to if he was above ground. (In addition, of course, he would be fully protected from fallout in the tube.)

Large-Scale Field Test ($^1/40$) at Suffield, Alberta

The test is fully described in an A.W.R.E. report[6]. The decision of the Canadian Defence Research Board to explode very large amounts of high explosive provided a medium for a variety of target-response trials that was welcome at a time when nuclear tests in Australia were suspended. A.W.R.E. used the 100-ton explosion in 1961 to test, among other items, the model length of the London tube, at $^1/40$th scale, that had already been tested at $^1/117$ scale.

Blast Entry from Stations

There was remarkable agreement with the $^1/117$th scale trials: "maximum overpressure in the train tunnels was of the order of $\frac{1}{3}$rd the corresponding peak shock overpressure in the incident blast. The pressures in the stations were about $^1/6$th those in the corresponding incident blast .... ".

(6) $^1/40$th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System. A.W.R.E. Report E2/62. (Official Use Only.)

100 ton TNT test on 1000 ft section of London Underground tube at Suffield, Alberta, 3 Aug 1961

Atomic Weapons Research Establishment, "1/40th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System", Report AWRE-E2/62, 1962, Figure 30. (National Archives ES 3/57.)

200 FT FROM GROUND ZERO	400 FT FROM GROUND ZERO
100 PSI OUTSIDE	20 PSI OUTSIDE
30 PSI IN TUBES	7.2 PSI IN TUBES
15 PSI IN TUBE STATIONS	4.3 PSI IN TUBE STATIONS

Aldwych Underground tube station as Blitz shelter, 8 October 1940

Aldwych tube London 21 Oct 1940: effective Blitz air raid shelter

THOSE WHO WENT TO SHELTERS began a new kind of night-life. Some took over the Tubes, camping out in this fashion—Elephant and Castle Station, 11th November, 1940.

UK NATIONAL ARCHIVES: HO225/16 (1950)

THE NUMBER OF ATOMIC BOMBS EQUIVALENT TO THE LAST WAR AIR ATTACKS ON GREAT BRITAIN AND GERMANY

Summary

During the last war, a total of 1,300,000 tons* of bombs were dropped on Germany by the Strategic Air Forces. If there were no increase in aimi[ng] accuracy, then to achieve the same total amount of material damage (to houses, industrial and transportation targets, etc.) would have required the use of over 300 atomic bombs together with some 500,000 tons of high explosive and incendiary bombs for targets too small to warrant the use of an atomic bomb. Increases in accuracy could cause a substantial reduction in this figure of 300 atomic bombs, to as few as 100-150 bombs for very accurate attacks.

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OFFICE OF THE CHIEF SCIENTIFIC ADVISER

A COMPARISON BETWEEN THE NUMBER OF PEOPLE KILLED PER TONNE OF BOMBS DURING WORLD WAR I AND WORLD WAR II

BOMB SIZES

=> ≈ 175 kg

For World War II the average bomb weight was between 150 - 200 kg. (R.C. 268, Table 6), whereas for World War I the majority of bombs were 12 or 50 kg.

TABLE 5

Relative safeties in World War II deduced from population and casualty distribution

	In the open	Under cover	In shelter
Population exposure	5%	60%	35%
Location people killed	19%	62%	19%
Relative safety	72%	20%	10%
RELATIVE DANGER!			

(1) A house about $3\frac{1}{2}$ times as safe as in the open.
(2) A shelter about twice as safe as a house.

Table 6 also shows the location of killed which is implied by each of the possible population exposures. The only evidence available on this point is that, for the day raid on June 13th, 1916, in which the total number killed was 59, 69.5% of the people killed in the City were in the open.

SECRET.

W.P.(G)(41)7. COPY NO. 62

January 15th, 1941.

WAR CABINET.

AIR RAID SHELTER POLICY.

Memorandum by the Minister of Home Security.

---

6. Shelter in the home: The Anderson shelter was originally intended for indoor use but for a number of reasons including the danger of fire an outdoor variant was adopted. Experience has shown that the objections to the indoor use of the Anderson or somewhat similar shelter are not so serious as was thought and two designs have been produced which can be erected indoors without support. These new types, although they may give slightly less protection than a well covered Anderson shelter out of doors, would fill the needs of a large section of the public, especially the middle class. One design allows the use of the shelter as part of the furniture of the room.

7. I regard shelters of this type as of the first importance and wish to provide them on a big scale. Each shelter will use over 3 cwt. of steel and will allow at a pinch two adults and one to two children to sleep inside. For an outlay of about 65,000 tons of steel, as a first instalment, I could therefore produce 400,000 shelters with accommodation for at least 1,000,000 persons. I should wish to complete such a programme within the first three months of production and thereafter at a similar or increasing rate. From enquiries I believe that manufacture can be arranged provided steel is supplied and if the Cabinet approves my policy I shall require their direction that the steel be made available.

10. Conclusions.

I ask for a general endorsement of the policy I have outlined in this paper and in particular for the agreement of my colleagues:

(i) that proposals for building shelters of massive construction should be rejected;

(ii) that steel should be made available to carry out the programme outlined in paragraph 7 for the provision of steel shelters indoors;

(iii) that the limit of income for the provision of free shelter for insured persons should be raised from £250 to £350 per annum.

H.M.

MINISTRY OF HOME SECURITY.

January 15th, 1941.

Morrison Shelters in Recent Air Raids.

A report of Ministry of Home Security experts on 39 cases of bombing incidents in different parts of Britain covering all those for which full particulars are available in which Morrison shelters were involved shows how well they have stood up to severe tests of heavy bombing.

All the incidents were serious. Many of the incidents involved direct hits on the houses concerned a risk against which it was never claimed these shelters would afford protection. In all of them the houses in which shelters were placed were within the radius of damage by bombs; in 24 there was complete demolition of the house on the shelter.

A hundred and nineteen people were sheltering in these "Morrisons" and only four were killed. So that 115 out of 119 people were saved. Of these only 7 were seriously injured and 14 slightly injured while 94 escaped uninjured. The majority were able to leave their shelters unaided.

Reprinted as amended in accordance with the Decision of the Assistant Comptroller, acting for the Comptroller-General, dated the nineteenth day of July, 1944, under Section 11, of the Patents and Designs Acts, 1907 to 1942.

PATENT SPECIFICATION

Application Date: Sept. 20, 1940. No. 14411/40.

544,710

Complete Specification Left: April 4, 1941.

Complete Specification Accepted: April 24, 1942.

PROVISIONAL SPECIFICATION

A Protective Shield for Beds and the like

I, ALFRED ETHELBERT MOSS, a British Subject, of 20, William IVth Street, Charing Cross, London, W.C.2, do hereby declare the nature of this invention to be as follows:—

This invention has for its object to provide a protective shield for beds and the like, to protect the occupant from injury by projectiles or falling splinters or the like, and also from the collapse or partial collapse of the building, or, in general terms, to ensure a certain measure of protection against injury during air-raids.

According to this invention, a protective shield for a bed or the like comprises standards supporting a roof-like structure over the bed.

The roof may be of composite form comprising a plate, grid or like strong element to support a weight collapsing upon it, and a yielding material such, for example, as a mattress lying on top of the plate or other member, to resist penetration by projectiles, falling splinters or the like.

If desired, additional protection may be provided by means of side screens supported from the top of the shield and constituted by a wire mesh, grid or like flexible material.

The details of mechanical construction of the shield may be varied according to specific requirements and according to the materials which are available. In one embodiment, the shield may be provided with a base constituted by a rectangular frame built up of angle-irons to surround the bed, with an upright at each corner. These also may be of angle-iron and they support at their upper end a rectangular frame similar to that at the base, and the top frame may be provided with cross-bracing if so desired. A steel plate can be laid on the top frame, or secured thereto and this plate, for convenience in handling, may be divided into sections. Instead of a rigid plate a grid or wire mesh or the like may be substituted for it. The object of this plate or equivalent device is to withstand the heavy loads which may arise on collapse of the building, or from a ceiling falling.

On top of the strong element of the roof there is laid a cushioning material, such as a mattress or the like, which will effectively stop flying fragments or splinters.

Side screens may be provided, supported from the various members of the upper frame, to afford protection against fragments which are travelling more or less horizontally; these screens may be rigid plates but, preferably, are of a flexible nature, such, for example, as a stout wire mesh sheet or some equivalent material.

The structure is preferably made of sufficient size closely to enclose the bed, and extends to a height of, say, 4 feet above the bed so that a patient can sit upright in the bed or be attended to whilst in bed.

In a modified construction, instead of using a base frame, each of the standards at the four corners of the bed may be independently carried on a base-plate which, preferably, will be screwed or otherwise secured to the floor. Instead of using angle-irons, steel tubes may be used to construct the frame, or if steel is not available, wooden poles of a suitable size may be used for the uprights, and these would be conveniently mounted in sockets in the base-plate. The top frame would similarly be provided with sockets to engage the upper ends of the poles.

Instead of securing the structure to the floor, the standards could be clamped to the bed-frame itself, or to the bed-posts, or if desired the bed-posts could be extended upwards to a height of 4-feet or so above the bed, and the top frame secured on them to carry the protective shields.

The shield according to this invention may, of course, be used for protecting any bed, but it is of particular value in hospitals and like institutions where it may not be possible to remove the patients in times of emergency, as a very considerable measure of protection can be afforded to them.

Dated this 20th day of September, 1940.

BOULT, WADE & TENNANT,
Chartered Patent Agents,
111 & 112, Hatton Garden,
London, E.C.1.

COMPLETE SPECIFICATION

A Protective Shield for Beds and the like

I, ALFRED ETHELBERT MOSS, a British Subject, of 20, William IVth Street, Charing Cross, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention has for its object to provide a protective shield for beds and the like, the protect the occupant from injury by projectiles or falling splinters or the like, and also from the collapse or partial collapse of the building, or, in general terms, to ensure a certain measure of protection against injury during air-raids. It is not concerned with covers such as are provided on children's cots to prevent the occupant climbing out, or with enclosures such as mosquito-nets.

According to the invention, a protective shield for a bed or the like comprises uprights supporting a roof-like strength member, such as a plate or grid to support a weight collapsing upon it and side-screens to provide lateral protection against flying fragments and the like. There may also be provided a yielding material on the strength-member aforesaid to resist penetration by flying fragments.

The details of mechanical construction of the shield may be varied according to specific requirements and according to the materials which are available.

The accompanying drawings, Figures 1 and 2, illustrate various constructions according to the present invention.

In Figure 1, the shield is of a form to provide protection for an ordinary bed. It comprises a base 10 constituted by a rectangular frame built up of angle-irons and is of such a size as to surround the bed, with uprights 11 at the four corners. These also may be of angle-iron, and they support at their upper end the rectangular frame 12 which may be similar to that constituting the base, and this top frame may be provided with cross-bracing, indicated at 13, if so desired. A steel plate 14 is laid on the top frame, or secured thereto, and whilst it may be made in one piece it may, alternatively, for convenience in handling, be divided into sections.

Instead of a rigid plate, a grid or wire mesh or equivalent device may be substituted for it, the object of this plate or equivalent device being to withstand the loads which may arise on the collapse of the building or from the ceiling falling on it. On top of the plate 12 or equivalent strong element of the roof, there may be provided a cushioning material 15, such as a mattress or the like, which will effectively stop flying fragments or splinters, it being well-known that such fragments are more effectively stopped by a yielding material than by a rigid material.

In order to provide protection against fragments which are travelling more or less horizontally, side screens 16 are provided, extending between the upper frame 12 and the base 10; these screens could be rigid plates but are preferably of a flexible nature, such as a stout wire mesh screen or an equivalent structure, and one or more of them may be readily detachable to provide easy access to the bed.

This structure is made of sufficient size to enclose the bed and in this particular form the uprights 11 are of sufficient length to extend to a height of, say, four feet above the bed so that a patient can sit upright in the bed or be attended to whilst in the bed.

Figure 2 shows a modified construction of a similar shelter. In this case each of the uprights 17 is independently carried on a base-plate 18 which is screwed or otherwise secured to the floor, and they carry a top frame which is illustrated as being provided with an open screen, but may be constructed as described with reference to Figure 1.

Figure 2 also shows that instead of using angle-irons for the structure, steel tubes may be used for the various members, these tubes being connected together by suitable sockets 19.

Any of the forms of the invention may be constructed with wood or any other suitable material which is available for the purpose.

The bed may be supported from the uprights of the shield or alternatively the uprights of the shield may be secured to the posts of the bed in any convenient manner.

In the constructions illustrated the top shield is shown as flat, but if desired it may be sloped, for example from one end to the other, or it may be of an inverted V formation, so that a proportion at least of the debris falling on it will fall off, and thereby reduce the load which it has to support.

The shield according to this invention may, of course, be used for protecting any bed, but it is of particular value in hospitals and like institutions where it may not be possible to remove the patients in times of emergency, as a very considerable measure of protection can be afforded to them.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A protective shield for a bed or the like, comprising uprights supporting a roof-like strength-member, such as a plate or grid to support a weight collapsing upon it and side-screens to provide lateral protection against flying fragments and the like.

2. A shield according to claim 1, comprising also a yielding material on the strength-member to resist penetration by projectiles, flying splinters and the like.

3. A shield according to claim 1 or claim 2, comprising a base-frame provided with uprights and a top frame supported on said uprights with a strength-member carried by said top frame.

4. A shield according to claim 1, constructed as a unit separate from, but adapted to enclose, the bed.

5. A shield according to claim 1, wherein the bed is supported on the uprights of the shield.

6. A shield according to claim 1, whereof the uprights are independently secured to the floor.

7. A shield according to claim 1, wherein the uprights are secured to the posts of the bed.

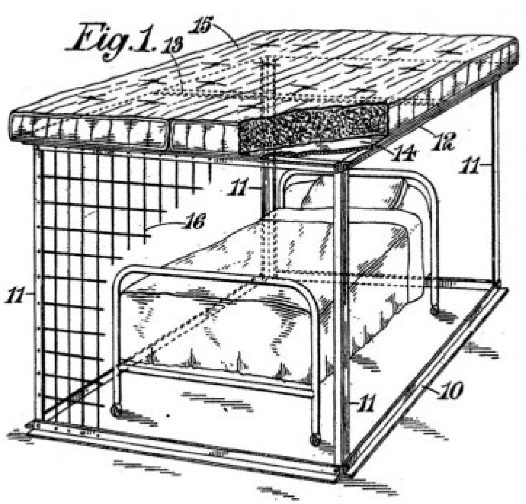
8. A shield according to any of the preceding claims, wherein the roof is sloped, for the purpose set forth.

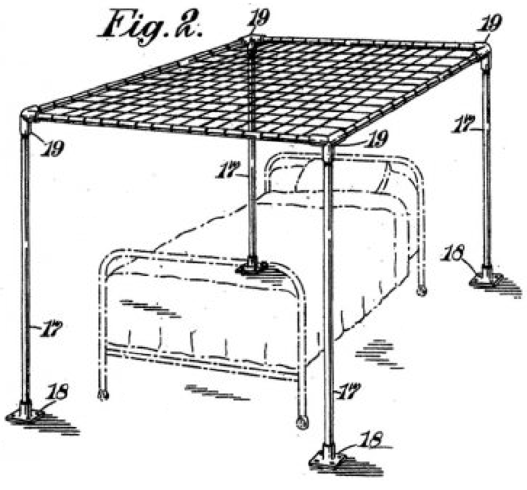
9. The improved shield for a bed or the like, substantially as described with reference to the accompanying drawings.

Dated this 4th day of April, 1941.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden,
London, E.C.1.
Chartered Patent Agents,

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1944.





November 1940 design by C. A. Joy, M. Inst. Me. & C. E., Bexley Borough Engineer (UK National Archives: HO 205/257)

ANDERSON SHELTER

(Indoors to avoid groundwater flooding, damp and cold)

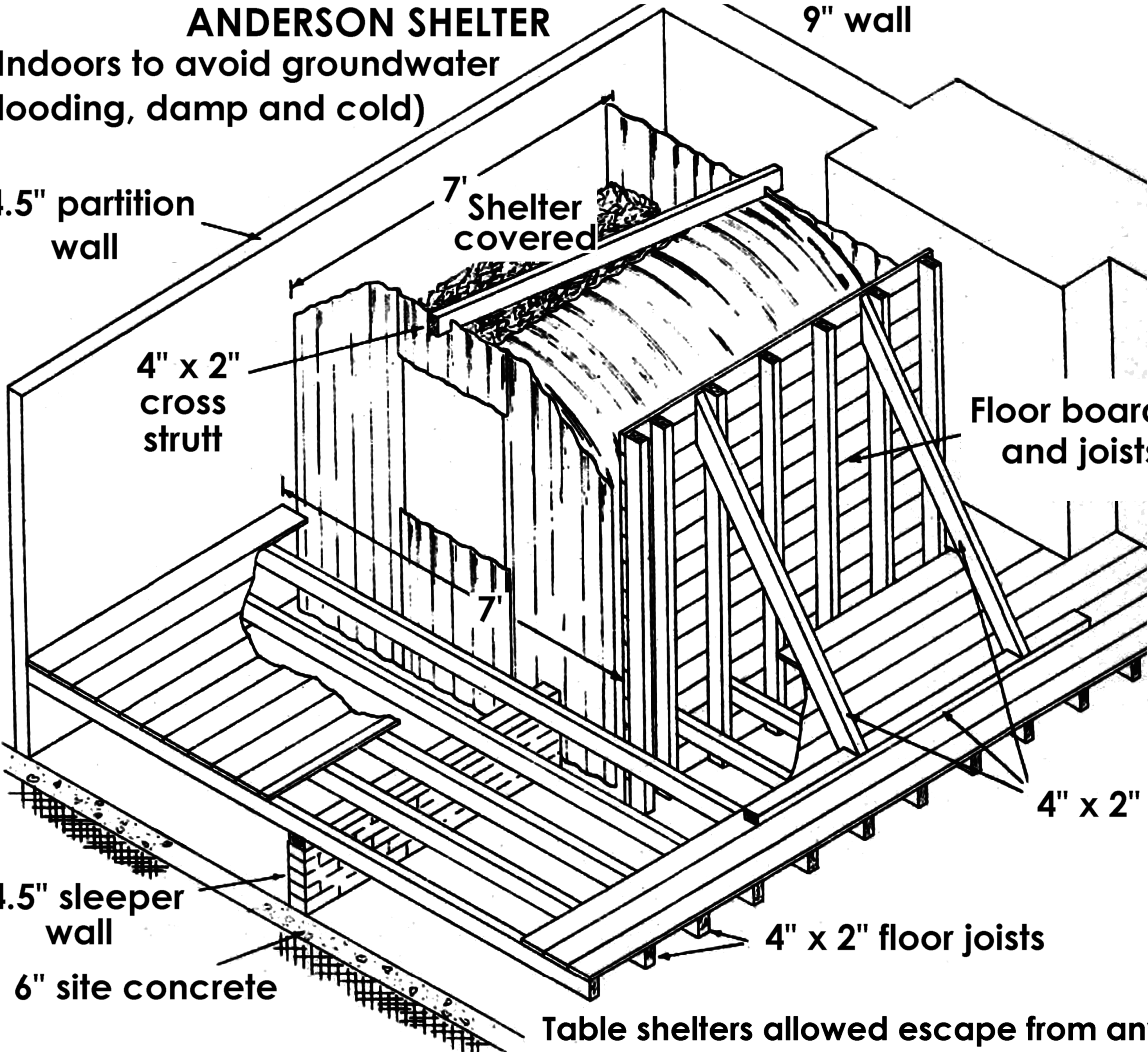
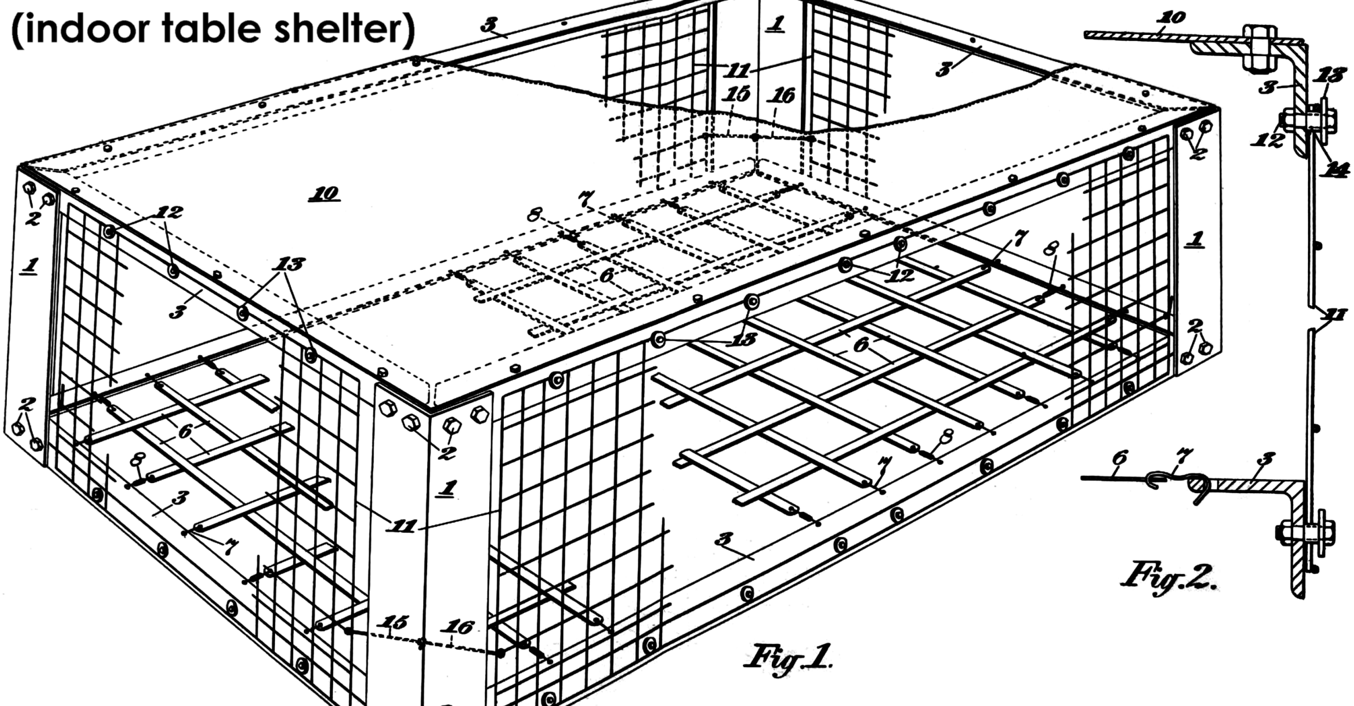


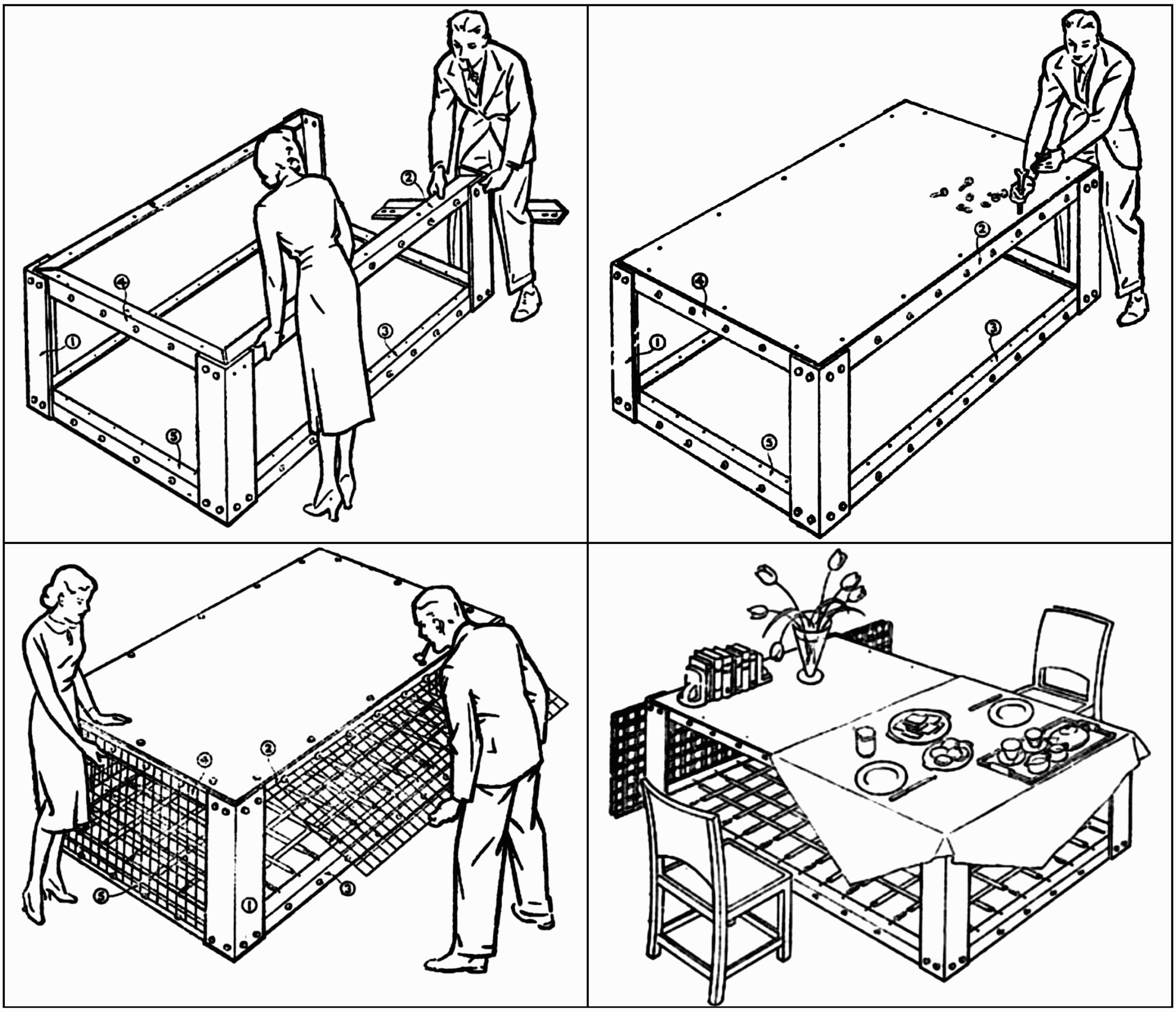
Table shelters allowed escape from any side easily, reducing fire risks

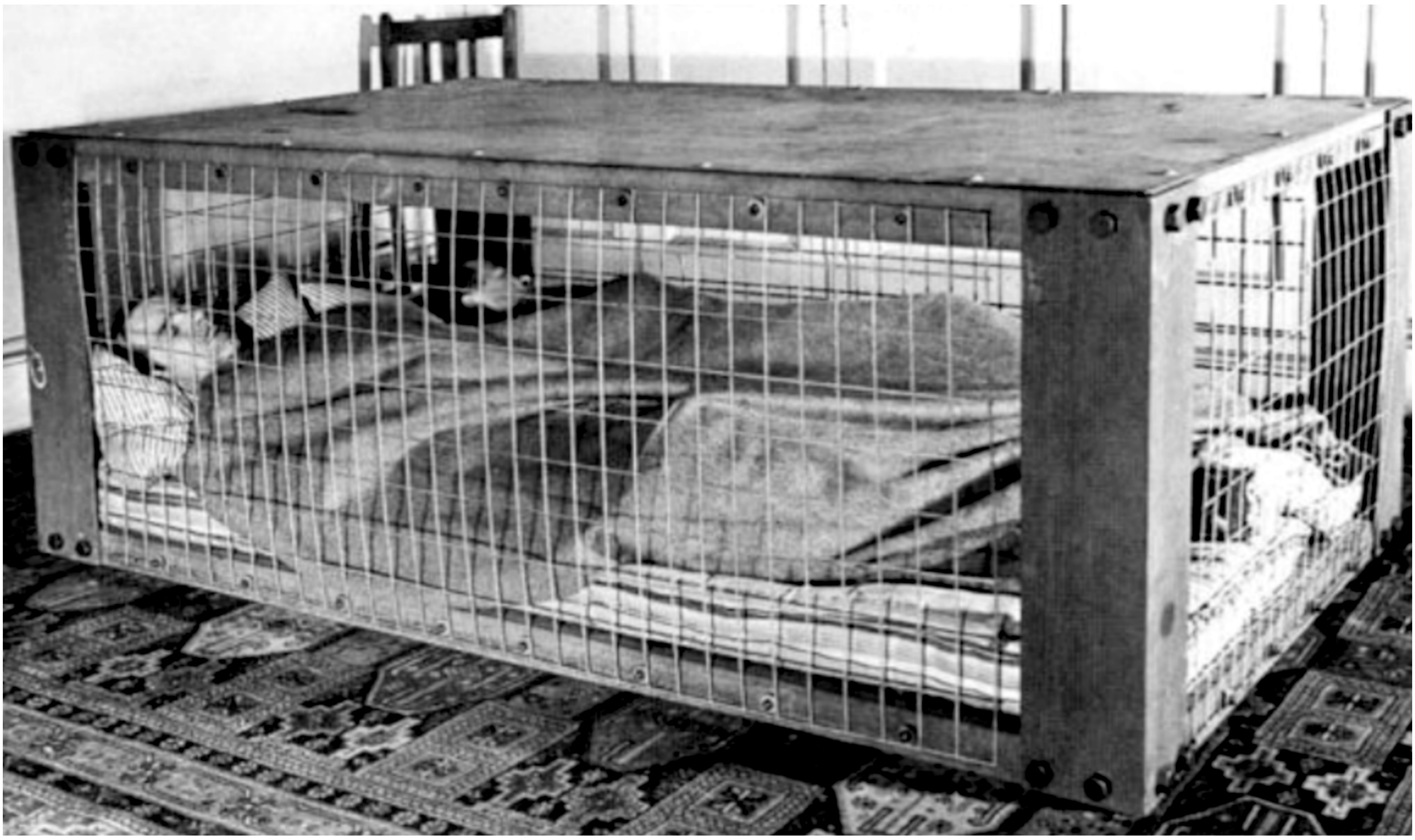
MORRISON SHELTER

(indoor table shelter)



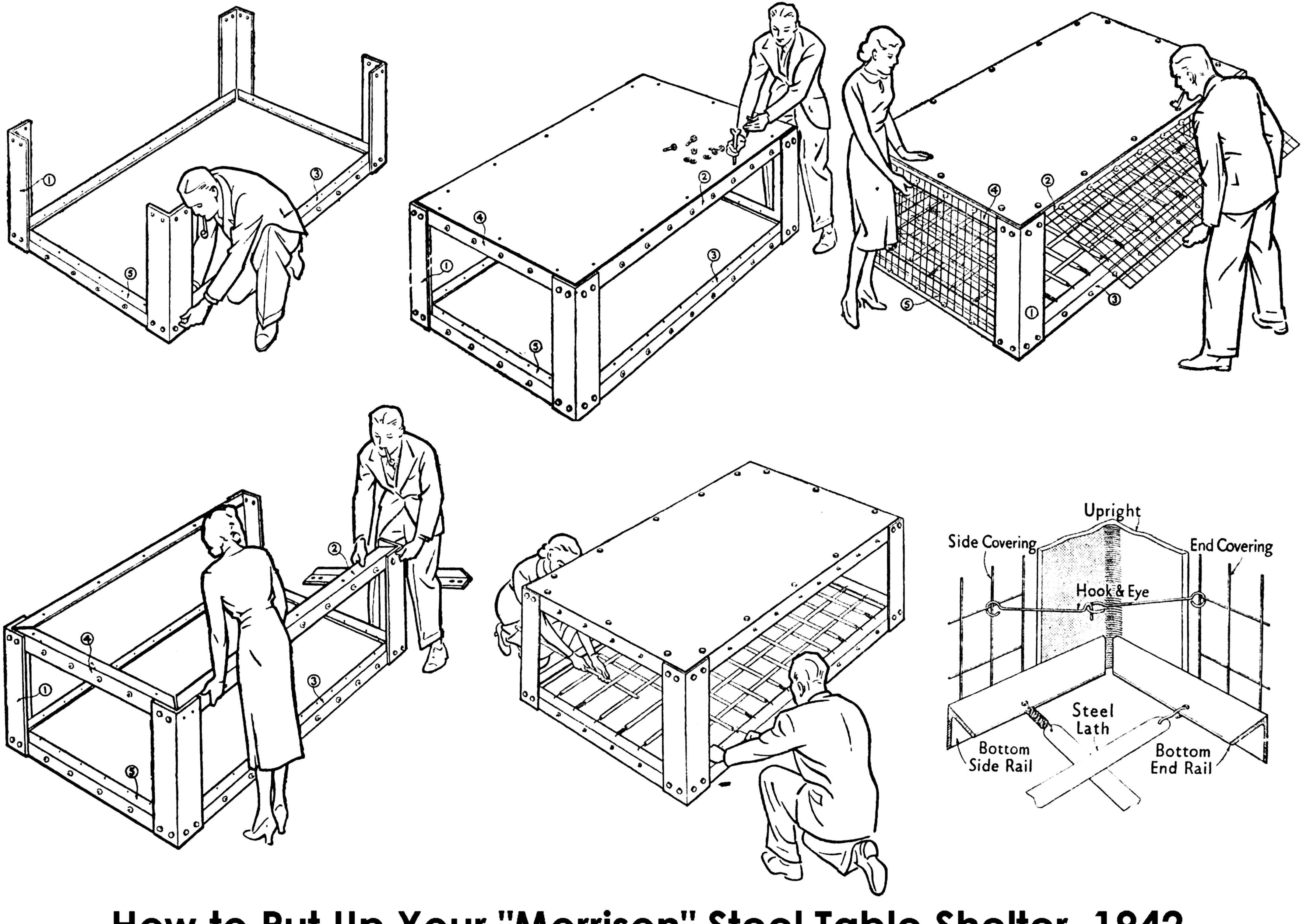
Patent specification by Prof. John Fleetwood Baker, Ministry of Home Security (National Archives HO 356/10)





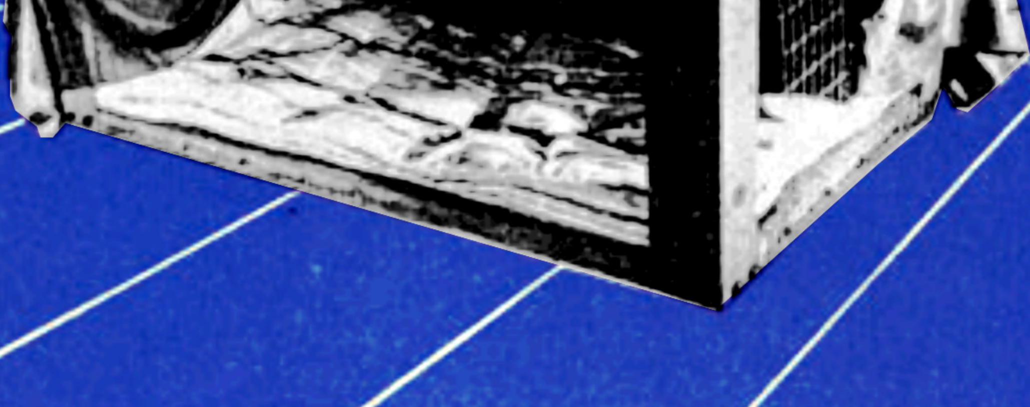
Structural Defense, 1945, by D. G. Christopherson, Ministry of Home Security, RC 450, (1946); Chapters VIII and IX (Confidential). Chapter VIII summarizes the literature on the design and types of British shelters and analyzes their effectiveness.

National Archives
HO 195/16



How to Put Up Your "Morrison" Steel Table Shelter, 1942

SHELTER at home



3d. ISSUED BY THE MINISTRY OF HOME SECURITY AND PUBLISHED BY H.M. STATIONERY OFFICE

ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.

(Page 11 from the June 1941 UK Ministry of Home Security "Shelter at Home" handbook.)





Morrison shelter saves lives of Mr McGregor pictured beside Morrison shelter, as well as his wife and lodger, in collapsed house, York 1942 air raid


Morrison indoor table shelter test by Ministry of Home Security, 1941: result shelter survived and occupants would have escaped unaided. (Source: "Shelter at Home", June 1941 handbook.)

Morrison shelter saves lives of Mr McGregor (pictured beside Morrison shelter), as well as his wife and lodger, in collapsed house, York 1942 air raid

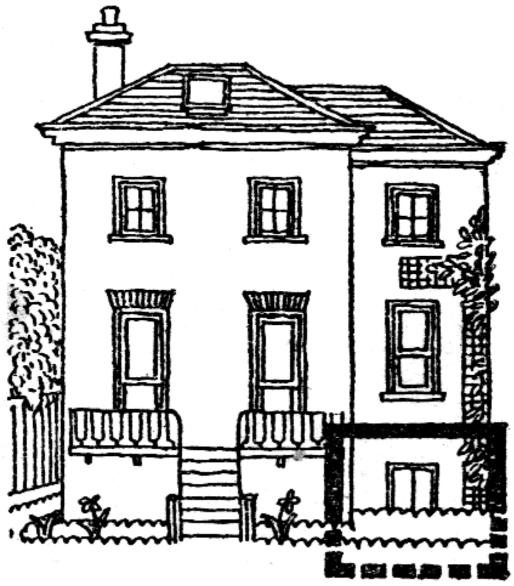
HOME OFFICE

THE PROTECTION OF YOUR HOME AGAINST AIR RAIDS

READ THIS BOOK THROUGH
THEN
KEEP IT CAREFULLY

HOW TO CHOOSE A REFUGE-ROOM

Almost any room will serve as a refuge-room if it is soundly constructed, and if it is easy to reach and to get out of. Its windows should be as few and small as possible, preferably facing a building or blank wall, or a narrow street. If a ground floor room facing a wide street or a stretch of level open ground is chosen, the windows should if possible be specially protected (see pages 30 and 31). The stronger the walls, floor, and ceiling are, the better. Brick partition walls are better than lath and plaster, a concrete ceiling is better than a wooden one. An internal passage will form a very good refuge-room if it can be closed at both ends.

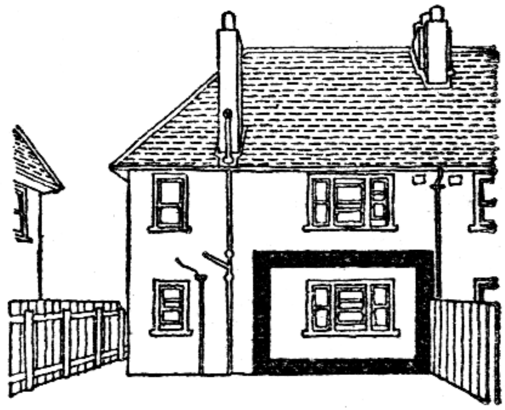


A cellar or basement is the best position for a refuge-room if it can be made reasonably gas-proof

The best floor for a refuge-room

A cellar or basement is the best place for a refuge-room if it can be made reasonably gas-proof and if there is no likelihood of its becoming flooded by a neighbouring river that may burst its banks, or by a burst water-main. If you have any doubt about the risk of flooding ask for advice from your local Council Offices.

Alternatively, any room on any floor below the top floor may be used. Top floors and attics should be avoided as they usually do not give sufficient protection overhead from small incendiary bombs. These small bombs would probably penetrate the roof but be stopped by the top floor, though they might burn through to the floor below if not quickly dealt with.

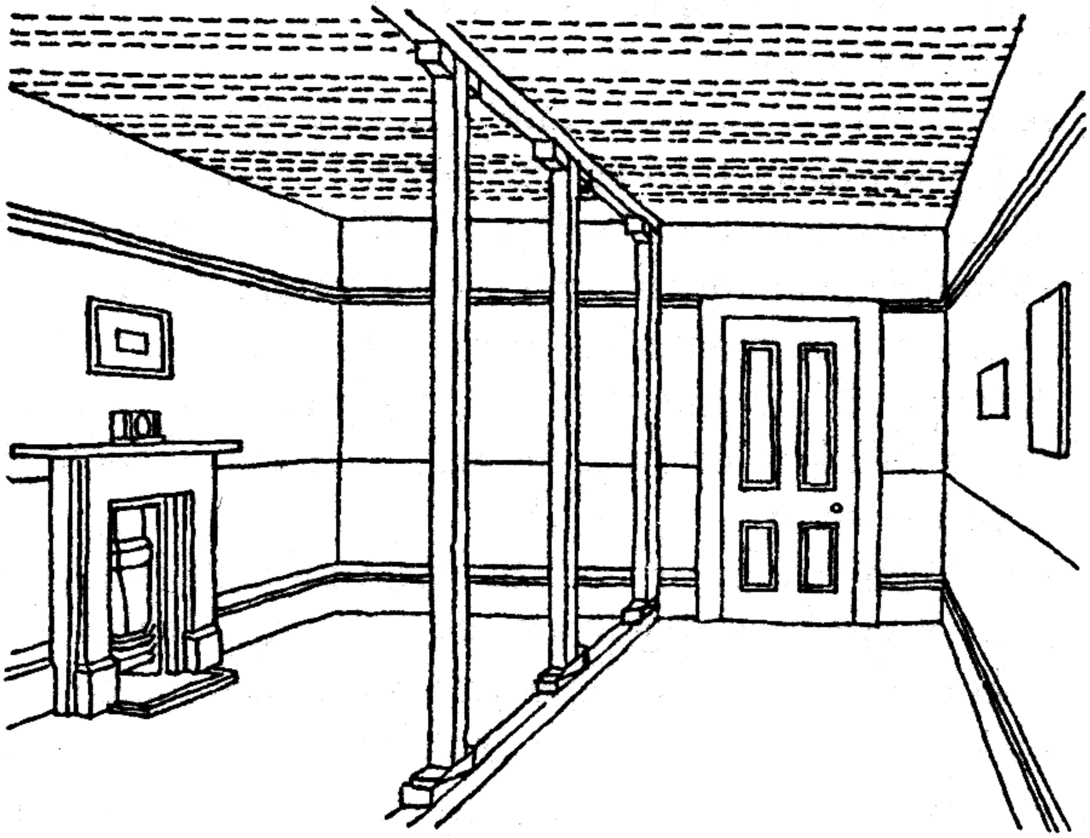


In a house with only two floors and without a cellar, choose a room on the ground floor so that you have protection overhead

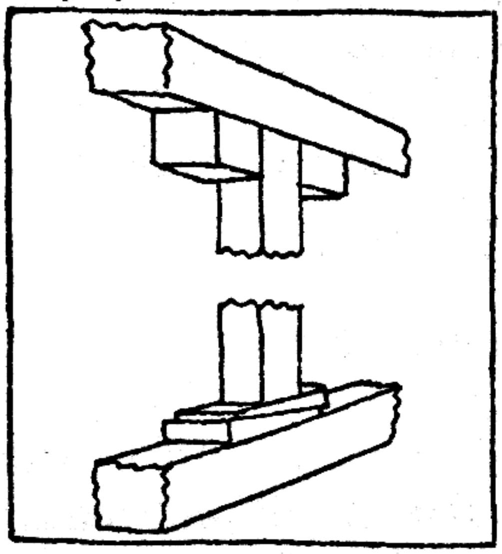
Strengthening the room

If your refuge-room is on the ground floor or in the basement, you can support the ceiling with wooden props as an additional protection. The illustration shows a way of doing this, but it would be best to take a builder's advice before setting to work. Stout posts or scaffold poles are placed upright, resting on a thick plank on the floor and supporting a stout piece of timber against the ceiling, at right angles to the ceiling joists, i.e. in the same direction as the floor boards above.

How to support a ceiling



The illustration below shows the detail of how to fix the props

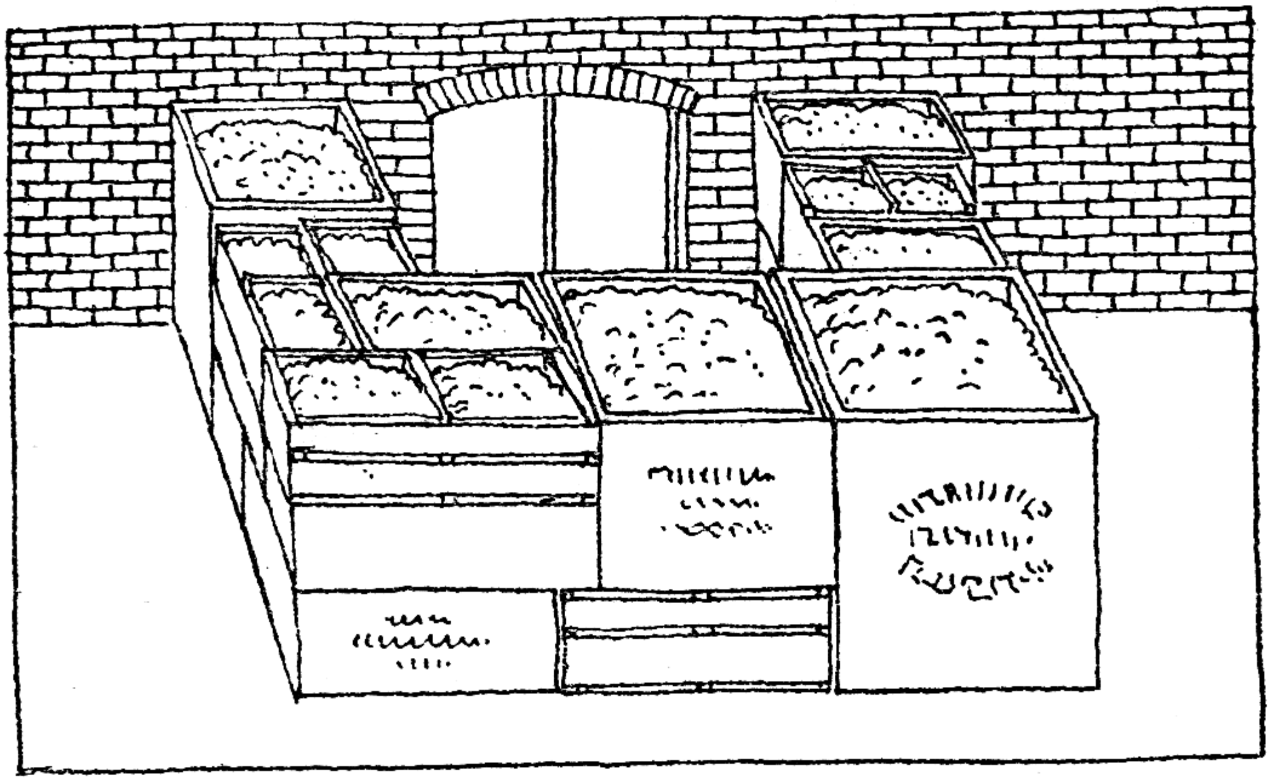


The smaller illustration shows how the posts are held in position at the top by two blocks of wood on the ceiling beam. The posts are forced tight by two wedges at the foot, driven in opposite ways. Do not drive these wedges too violently, otherwise you may lift the ceiling and damage it. If the floor of your refuge-room is solid, such as you might find in a basement, you will not need a plank across the whole floor, but only a piece of wood a foot or so long under each prop.

EXTRA PRECAUTIONS AGAINST EXPLOSIVE BOMBS

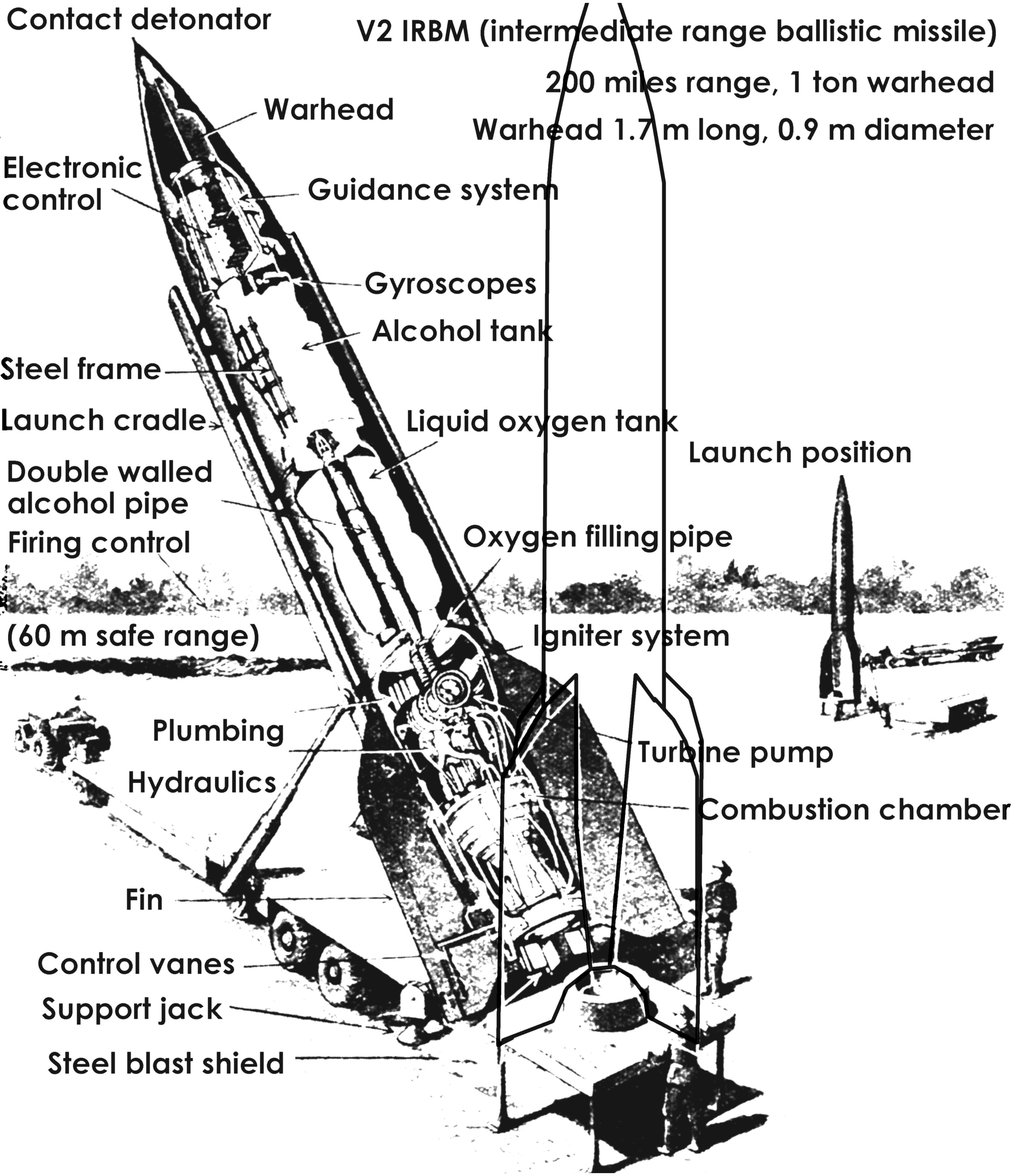
TRENCHES. Instead of having a refuge-room in your house, you can, if you have a garden, build a dug-out or a trench. A trench provides excellent protection against the effects of a bursting bomb, and is simple to construct. Full instructions will be given in another book which you will be able to buy. Your air raid wardens will also be able to advise.

SANDBAGS. Sandbags outside are the best protection if your walls are not thick enough to resist splinters. Do not rely on a wall keeping out splinters unless it is more than a foot thick. Sandbags are also the best protection for window openings. If you can completely close the window opening with a wall of sandbags you will prevent the glass being broken by the blast of an explosion, as well as keeping out splinters. But the window must still be sealed inside against gas.



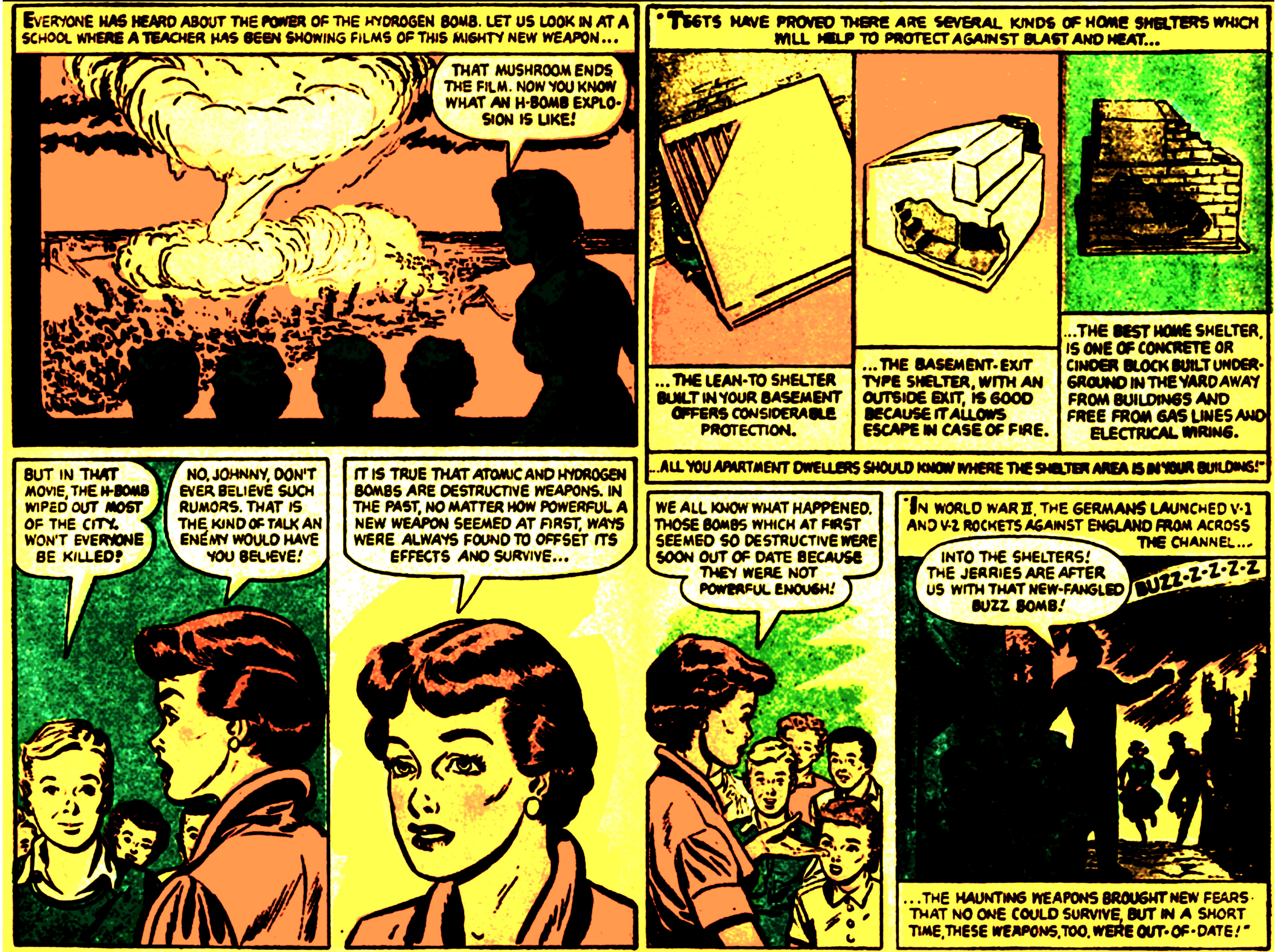
A basement window protected by boxes of earth

Any bags or sacks, including paper sacks such as are used for cement, will do for sandbags. But if they are large, don't fill


Contact detonator
V2 IRBM (intermediate range ballistic missile)
200 miles range, 1 ton warhead
Warhead 1.7 m long, 0.9 m diameter
Warhead
Electronic control
Guidance system
Gyroscopes
Alcohol tank
Steel frame
Launch cradle
Liquid oxygen tank
Launch position
Double walled alcohol pipe
Firing control
Oxygen filling pipe
(60 m safe range)
Igniter system
Plumbing
Turbine pump
Hydraulics
Combustion chamber
Fin
Control vanes
Support jack
Steel blast shield

Aldwych, 30 June 1944, V1 attack

V–2 ATTACK at Smithfield Market, London, where 110 people were killed and 123 seriously injured when pavements were crowded



EVERYONE HAS HEARD ABOUT THE POWER OF THE HYDROGEN BOMB. LET US LOOK IN AT A SCHOOL WHERE A TEACHER HAS BEEN SHOWING FILMS OF THIS MIGHTY NEW WEAPON...
THAT MUSHROOM ENDS THE FILM. NOW YOU KNOW WHAT AN H-BOMB EXPLOSION IS LIKE!
BUT IN THAT MOVIE, THE H-BOMB WIPED OUT MOST OF THE CITY. WON'T EVERYONE BE KILLED?
NO, JOHNNY, DON'T EVER BELIEVE SUCH RUMORS. THAT IS THE KIND OF TALK AN ENEMY WOULD HAVE YOU BELIEVE!
IT IS TRUE THAT ATOMIC AND HYDROGEN BOMBS ARE DESTRUCTIVE WEAPONS. IN THE PAST, NO MATTER HOW POWERFUL A NEW WEAPON SEEMED AT FIRST, WAYS WERE ALWAYS FOUND TO OFFSET ITS EFFECTS AND SURVIVE...
"TESTS HAVE PROVED THERE ARE SEVERAL KINDS OF HOME SHELTERS WHICH WILL HELP TO PROTECT AGAINST BLAST AND HEAT...
...THE LEAN-TO SHELTER BUILT IN YOUR BASEMENT OFFERS CONSIDERABLE PROTECTION.
...THE BASEMENT-EXIT TYPE SHELTER, WITH AN OUTSIDE EXIT, IS GOOD BECAUSE IT ALLOWS ESCAPE IN CASE OF FIRE.
...THE BEST HOME SHELTER, IS ONE OF CONCRETE OR CINDER BLOCK BUILT UNDERGROUND IN THE YARD AWAY FROM BUILDINGS AND FREE FROM GAS LINES AND ELECTRICAL WIRING.
...ALL YOU APARTMENT DWELLERS SHOULD KNOW WHERE THE SHELTER AREA IS IN YOUR BUILDING!"
WE ALL KNOW WHAT HAPPENED. THOSE BOMBS WHICH AT FIRST SEEMED SO DESTRUCTIVE WERE SOON OUT OF DATE BECAUSE THEY WERE NOT POWERFUL ENOUGH!
"IN WORLD WAR II, THE GERMANS LAUNCHED V-1 AND V-2 ROCKETS AGAINST ENGLAND FROM ACROSS THE CHANNEL...
INTO THE SHELTERS! THE JERRIES ARE AFTER US WITH THAT NEW-FANGLED BUZZ BOMB!
BUZZ-Z-Z-Z-Z
...THE HAUNTING WEAPONS BROUGHT NEW FEARS THAT NO ONE COULD SURVIVE, BUT IN A SHORT TIME, THESE WEAPONS, TOO, WERE OUT-OF-DATE!"

CIVIL DEFENCE

RESCUE MANUAL

LONDON
HER MAJESTY'S STATIONERY OFFICE
1952

CHAPTER XI. USE OF HEAVY MECHANICAL PLANT IN RESCUE, DEMOLITION AND CLEARANCE OPERATIONS

In the last war it was found that at major incidents the use of heavy mechanical plant was frequently necessary in support of rescue operations. Such equipment was used to help in the quick removal of debris ; to lift heavy blocks of brickwork or masonry ; to take the weight of collapsed floors and girders so that voids could be explored and casualties extricated ; to haul off twisted steelwork and other debris and to break up sections of reinforced concrete.

In future all these tasks may be required and heavy clearance may have to be effected to enable rescue and other Civil Defence vehicles

8 March 1945

Fig. 20 **1 ton of TNT equivalent**

Using heavy mechanical plant at the Smithfield Market V.2 incident.

to approach within measurable distance of their tasks. The problem of debris will in fact be a major factor in Civil Defence operations.

Heavy mechanical plant may be required for the following purposes :

(*a*) To assist in the removal of persons injured or trapped. At this stage mainly heavy plant is needed, particularly mobile cranes with sufficient length of boom or jib to reach for long distances over the wreckage of buildings.

(*b*) To force a passage for Civil Defence vehicles and fire appliances to enable them to reach areas where major rescue and other problems exist and require urgent operational action.

(*c*) To take certain safety measures—e.g., to pull down unsafe structures.

(*d*) To clear streets and pavements to help restore communications and to afford access for the repair of damaged mains and pipes beneath the streets.

(*e*) For the final clearance of debris and the tidying of sites. This is a long term and not an operational requirement.

Urgent Rescue Operations

During rescue operations in London in the last war the machines used with great success included heavy $3\frac{1}{2}$-5 ton mobile cranes, mounted on road wheels, with a 30-40 ft. jib ; medium heavy 2-$3\frac{1}{2}$ ton mobile cranes, mounted on road wheels, with a 26 ft. jib ; heavy crawler tractor bulldozers ; medium crawler tractor bulldozers ; mechanical shovels and compressors, three stage, mounted on road wheels.

In the case of a large or multiple incident where access was obstructed by considerable quantities of scattered debris, a bulldozer or tractor was first employed in order to clear one or more approaches by which other equipment and personnel could reach the scene of operations.

Next, all debris of manhandling size was loaded into one-yard skips and discharged by the crane into lorries, giving increased manœuvring space to the Services operating on the site.

Heavy mobile cranes were then brought up to the incident where, used under the skilled direction of the rescue party Leader, they were invaluable for removing girders and large blocks of masonry which obstructed access to casualties or persons trapped. The necessary chains and wire ropes for these operations formed part of the standard equipment of the heavy and medium-heavy mobile cranes.

The work was, of course, carried out in close co-operation with the Rescue Parties who also used various forms of light mechanical equipment, such as jacks and ratchet lifting tackle for work in confined spaces.

Compressors sometimes proved valuable for breaking up large masonry such as fallen walls, into sections of a size and weight within the handling and lifting capacity of the cranes. This method was only used when it was known that there were no casualties under the masonry.

HOME OFFICE
SCOTTISH HOME DEPARTMENT

CIVIL DEFENCE HANDBOOK No. 7

Rescue

This Handbook is a revised edition of,
and replaces, the
Civil Defence Rescue Manual

LONDON
HER MAJESTY'S STATIONERY OFFICE
1960

CHAPTER 6

Types of Damage from Modern Air Attack

General Characteristics

6.1 When a nuclear weapon explodes an immense amount of energy is released almost instantaneously and the contents are transformed into a rapidly expanding white hot ball of gas at a temperature as high as that on the sun. From this "fireball" a pulse of intense light and heat is radiated in all directions. The materials in the fireball are also a source of radioactivity in various forms. As the fireball expands and cools, a powerful blast wave develops. As it cools still further, it shoots upwards to a height of many thousands of feet, billowing out at the top to give the appearance of a huge mushroom or cauliflower on its stalk.

6.2 The three forms of energy released in the explosion, namely, light and heat, radioactivity, and blast, all produce effects in different ways and in different proportions according to the position of the explosion in relation to the surface underneath. This chapter, however, deals primarily with the damage caused to buildings by the blast effect.

6.3 With nuclear weapons (as opposed to high explosive weapons), blast pressure rather than "impulse" tends to be the criterion of damage. If the effective blast pressure exceeds the static strength of the structure, failure must be expected. If it is less, no failure can occur however long the duration of the blast. In fact, nuclear bomb blast is more like a strong wind than the sudden blow of high explosive blast, and many of the failures observed at Hiroshima and Nagasaki and in subsequent tests resemble closely the kind of damage that might be done to buildings by a hurricane.

6.4 The scarcity of suction damage from the nominal bombs in Japan was due to the high blast pressures produced and to the fact that these were three or four times as great as the blast suction. With all such large explosions, if a building does not fail from blast pressure it is unlikely to fail under the lower stresses in the suction phase.

Effect of blast on structures

6.5 The type of damage which long duration blast (from nuclear weapons) causes to structures can possibly best be appreciated by considering the forces to which a simple building is subjected during the passage of a horizontal blast wave. When the blast "front" strikes the front wall it is reflected back, and the pressure in the wave front builds up to more than double the original pressure. However, this build-up only lasts for a very short time and is mainly important for large flat surfaces such as walls of big buildings.

Fig. 39 (a). Using a door as a stretcher

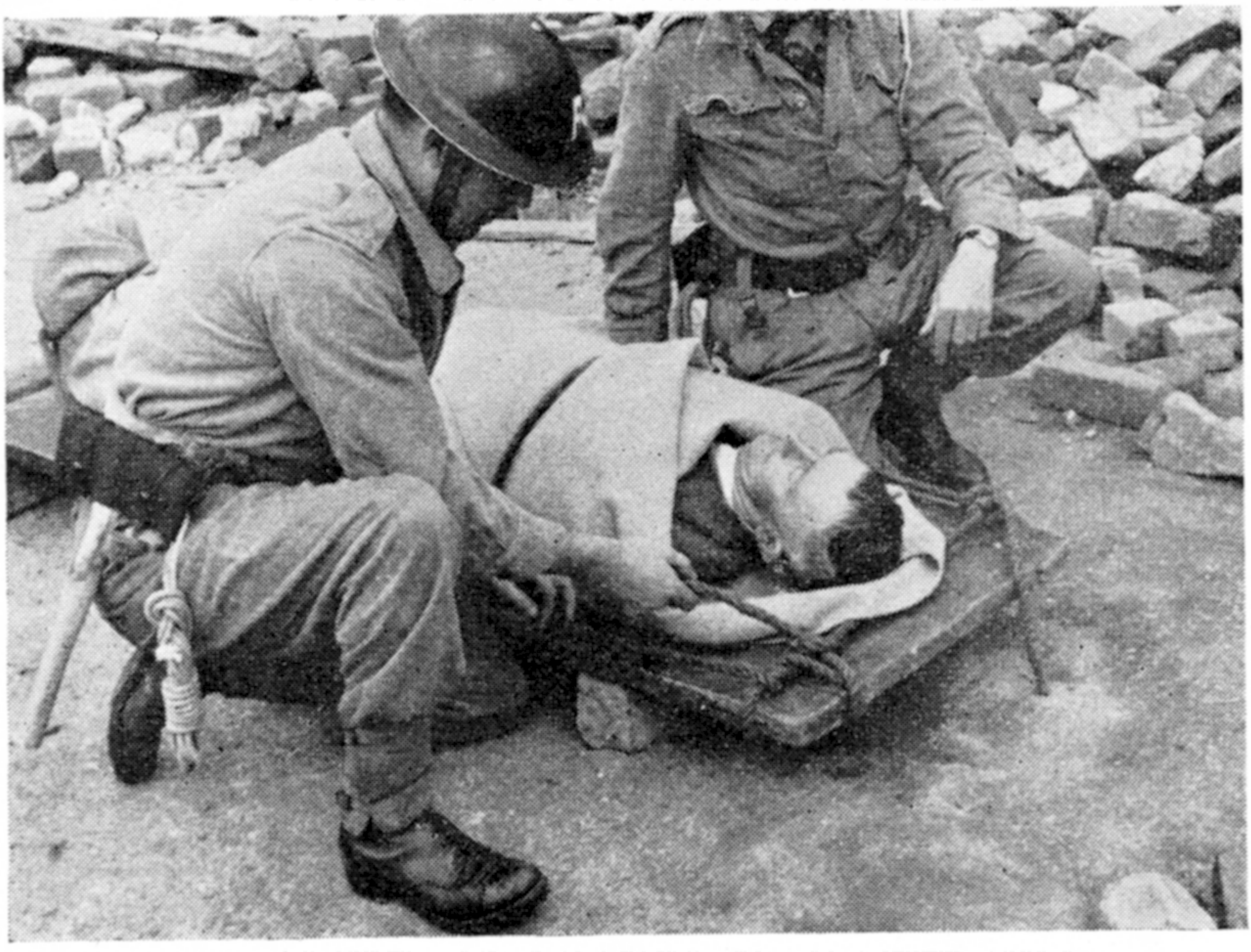


Fig. 39 (b). Using a door as a stretcher

CHAPTER 15

Principles of Levering and Jacking

15.1 The principles of levering and jacking are, in a variety of differing ways, brought into most aspects of rescue work. The purpose of lifting appliances is to gain power so as to lift a large load with a small force suitably applied.

Levers

15.2 The simplest appliance for gaining power is the lever, of which an improvised version made of laminated timber or an ordinary crowbar are most frequently used by rescue workers. There are two principal ways in which a lever can be used, as illustrated in the diagrams. In each case the advantage gained depends on the distance of (A), the centre of the load, and (C) the points where the push or force is applied from (B), the heel or fulcrum.

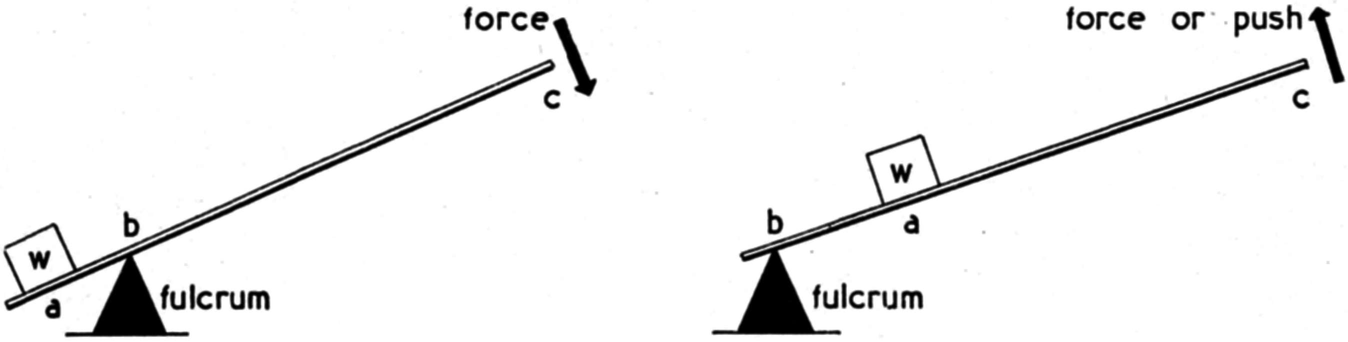


Fig. 68. Lever (downward force) Lever (upward force)

15.3 The relation between the load and the amount of force required to lift it is in the same ratio as the length BC is to AB, where AB and BC are the distances of the weight and the force respectively from the fulcrum. A man using a 10-foot lever and bearing down at C with half his weight, say, 6 stone or 84 lb., against a fulcrum 1 foot from the other end of the lever, can lift a weight of $84 \times 9 = 756$ lb. because the length from fulcrum to hand is nine times the length from pivot to weight. If B is only 6 inches away from the weight the ratio is increased to 19 times its own weight.

Fulcrum blocks

15.4 A fulcrum block should be of wood (hardwood if possible), never of brick or other crushable material. It must be resting on a firm base, which should be as large as possible so as to distribute the weight to be lifted. The fulcrum must be placed as near to the weight as is possible under the circumstances, and it should never be placed at any point where there is a possibility of a casualty being buried immediately below.

In 12 months, 1940-1, the Blitz stray dog Rip (discovered by civil defence rescuers in Poplar, East London after an air raid) sniffed out 100 trapped casualties in London rubble.

Irma. Margaret Griffin used Irma and Psyche to find 233 trapped persons

STANFORD RESEARCH INSTITUTE

STANFORD, CALIFORNIA

June, 1953

Final Report

IMPACT OF AIR ATTACK IN WORLD WAR II: SELECTED DATA FOR CIVIL DEFENSE PLANNING

Evaluation of Source Materials

By

Robert O. Shreve

SRI Project 669

Prepared for
Federal Civil Defense Administration
Washington, D. C.

Approved:

William J. Platt

William J. Platt, Chairman
Industrial Planning Research

Weldon B. Gibson

Weldon B. Gibson, Director
Economics Research Division

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 25 cents

Table 1

Report Outline - USSBS Project

IMPACT OF AIR ATTACK IN WORLD WAR II:
SELECTED DATA FOR CIVIL DEFENSE PLANNING

Division I - PHYSICAL DAMAGE TO STRUCTURES, FACILITIES, AND PERSONS

Volume 1 Summary of Civil Defense Experience
Volume 2 Analytical Studies (Restricted)
Volume 3 Causes of Fire from Atomic Attack (Secret) --VITAL!!

The documents which should be given wide distribution for civil defense use are listed below, with a brief description:

a. USSBS Reports

Effects of the Atomic Bomb on Hiroshima, Japan (3 volumes).

Effects of the Atomic Bomb on Nagasaki, Japan (3 volumes).

These reports constitute two case studies of atomic bombing. Civil defense planners should be aware of the facts these documents record in great detail. Their distribution to all civil defense planners and analysts is highly desirable.

-9-

Effects on Labor in Clydebank of Clydeside Raids of March 1941, (REN 234) USSBS Target Int.(REN 236) Ministry of Home Security

A study of the effects on labor of bombing in a town of 50,000 people in which 76% of houses were rendered uninhabitable, 73% of the population homeless. An equivalent of 65 city days was utilized in the reconstruction.

-22-

Ministry of Home Security
Effects of German Air Force Raids on Coventry (REN 441)

The city, the attack, casualties, repairs and reconstruction (cost), absenteeism, population movements, and housing occupancy. Six pages and charts and graphs. Twenty percent of houses rendered uninhabitable or destroyed, a total reconstruction cost of £ 3,492,000. Average time lost by worker after November raid was eleven days; average after April raid was 7 days. Nine percent of the workers evacuated to points within reach of the city.

NUMBER AND CLASSIFICATION OF OFFICIAL EVACUEES IN GREAT BRITAIN IN 1939 AND 1940

900,000 of the 1.5 million returned to the target areas after four months of war.	September, 1939		January, 1940	
	Number	Percentage Distribution	Number	Per cent of Those in September, 1939
1. Unaccompanied school children	826,959	56.1	457,600	55
2. Mothers and accompanied children	523,670	35.5	64,900	12
3. Expectant mothers	12,705	0.9	1,140	9
4. Blind persons, cripples, and other special classes	7,057	0.5	2,440	35
5. Teachers and helpers	103,000	7.0	46,500	45
Total	1,473,391	100.0	572,580	39

Source: R. M. Titmuss, *Problems of Social Policy* (London: H.M. Stationery Office, 1950), pp. 103 and 172.

Effectiveness of Some Civil Defense Actions in Protecting Urban Populations (u)

Appendix B of Defense of the US against Attack by Aircraft and Missiles (u)

ORO-R-17, Appendix B

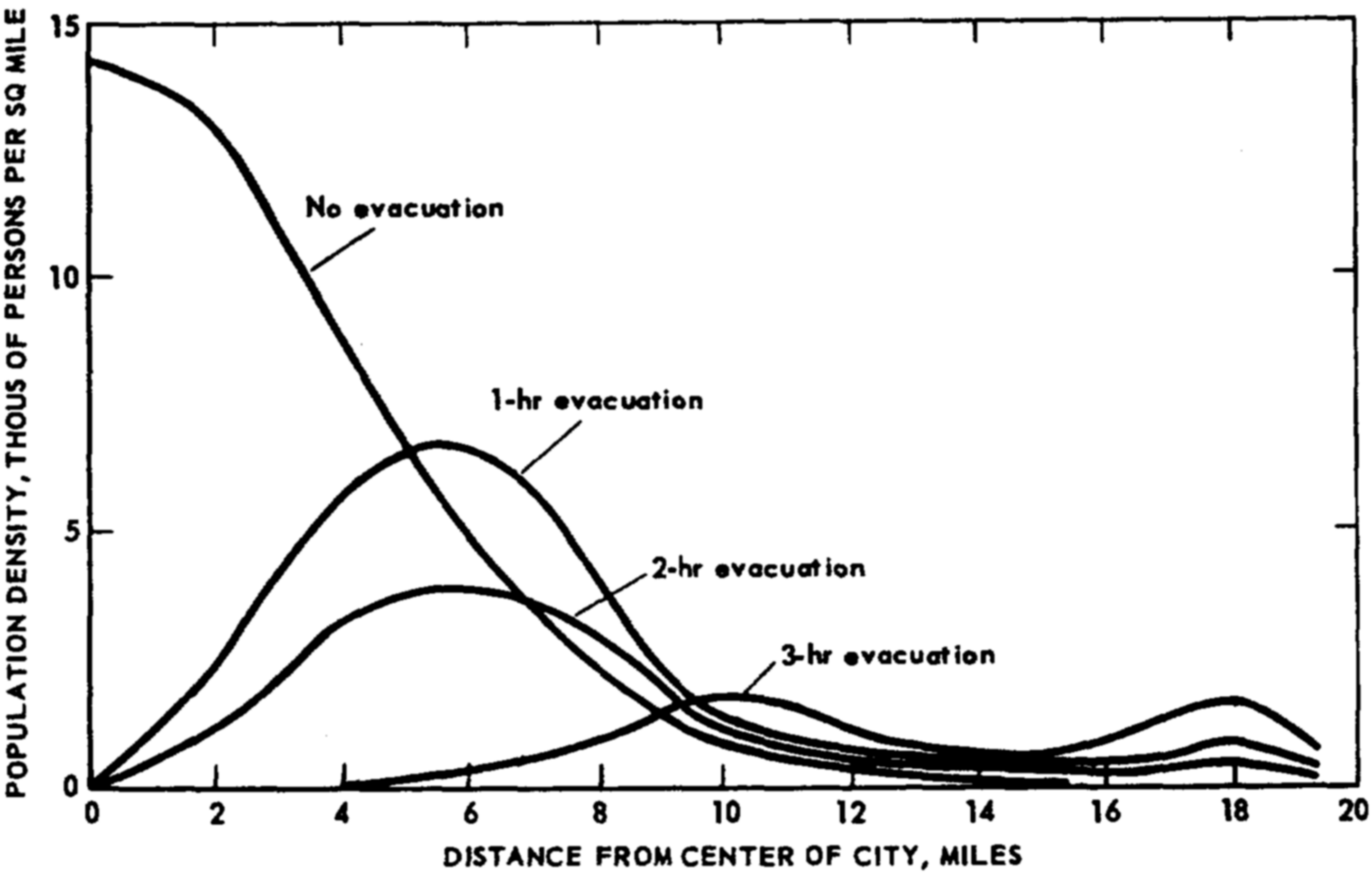


Fig. 10 — Population Density of Washington Target as Function of Distance from Center of City for Three Evacuation Times

Issued for the Ministry of Home Security
by the Ministry of Information

FRONT LINE

1940-41

The Official Story of the
CIVIL DEFENCE
of Britain

1942
London: His Majesty's Stationery Office

So far was all this from panic that it took three months for the population of the twenty-eight central boroughs to drop by about 25 per cent. from a little over 3,000,000 (the figure before heavy bombing began) to 2,280,000 at the end of November. In a group of the most heavily bombed eastern boroughs the pre-war population of 800,000 had fallen to 582,000 before the blitz began; for four months it had dropped steadily to 444,000; by 31st December a fall of 23 per cent. These figures do not spell panic, and a further substantial fall in 1941, after continuous heavy raiding had ceased, completes the evidence that those who went did so in cold blood, for practical reasons as valid for their hard-pressed city as for their private selves.

But what did all this mean to the average Londoner? In November, inner London (the county) contained some 3,200,000 people. Not more than 300,000 of these were in public shelter of any kind, half of that number at most in those larger shelters on which the limelight shone so exclusively. Nor is this all; in domestic shelter (Andersons, small brick shelters and private reinforced basements) there were no more than

1,150,000 people. Thus of every hundred Londoners living in the central urban areas, nine were in public shelter (of whom possibly four were in "big" shelters), 27 in private shelter, and 64 in their own beds—possibly moved to the ground floor—or else on duty. Particular big shelters, and for a few nights the tubes, were overcrowded, but there was public shelter for twice the number who made use of it. In outer London, with a population of some 4,600,000, there were in November 4 per cent. in public shelter, 26 per cent. in domestic shelter, and 70 per cent. at home or on duty.

In the last great war there had been outbursts of hate against the distant enemy, and shops with German names had been wrecked. This time the citizens did not stop for such things. After the first shock of realisation they found no more need for direct recrimination than does the soldier. Like him, they got on with the job and waited their chance. Neither in this nor in any other way was there a sign of instability; no panic running for shelter, no white faces in the streets (though plenty of taut, grim ones), no nerve disease. In all London, the month of October saw but twenty-three neurotics admitted to hospital. The mind-doctors had rather fewer patients than usual.

BLOCKED ROADS. The morning of 12th May: each raid sets the police still another traffic problem.

ENORMOUS CRATERS. At the Bank, where the road collapsed into the subway beneath. A temporary bridge was thrown right across it.


CITY OF COVENTRY
PREVENTION OF TYPHOID FEVER
In view of present damage to DRAINAGE communications in the City, special precautions against Typhoid Fever are advised:
BOIL ALL DRINKING WATER

The outcome may be seen in the following table, which shows coastal bombing to November, 1941, in round figures.

Town.	Number of Raids.	Civilians Killed.	Houses Damaged.
Fraserburgh ...	18	40	700
Peterhead ...	16	36	700
Aberdeen ...	24	68	2,000
Scarborough ...	17	30	2,250
Bridlington ...	30	24	3,000
Grimsby	22	18	1,700
Gt. Yarmouth ...	72	110	11,500
Lowestoft ...	54	94	9,000
Clacton	31	10	4,400
Margate ...	47	19	8,000
Ramsgate ...	41	71	8,500
Deal	17	12	2,000
Dover	53 (and shelling)	92	9,000
Folkestone ...	42	52	7,000
Hastings	40	46	6,250
Bexhill	37	74	2,600
Eastbourne ...	49	36	3,700
Brighton / Hove ... }	25	127	4,500
Worthing ...	29	20	3,000
Bournemouth ...	33	77	4,000
Weymouth ...	42	48	3,600
Falmouth ...	33	31	1,100

A PENGUIN SPECIAL

THE PSYCHOLOGY OF FEAR AND COURAGE

BY

EDWARD GLOVER

(Published for Blitz air raids in 1940)

PENGUIN BOOKS
HARMONDSWORTH MIDDLESEX ENGLAND
41 EAST 28TH STREET NEW YORK U.S.A.

Real knowledge, for example, is one of the best antidotes to unreal fear. *Useful action* is also an excellent preventive, and *vigorous preparation to meet real danger* will enormously reduce unreal fear. The strength of a common purpose will do the rest. Knowledge, a common purpose, and preparedness for action. These are the remedies for faintness of heart in the face of danger.

22

Now as to preparation. You may recall that when Napoleon was asked how he was always able to give an instant decision in a crisis, he replied: "Because I constantly prepare every detail in advance." Here is a discipline you can readily cultivate. Always make a point of knowing beforehand *exactly* what you are going to do in an air raid; whether you find yourself in house, street, train, bus or shelter. Have it word perfect.

23

A stray crowd packed into a cinema is likely to panic at the cry of "Fire." There are no common bonds between the people concerned; and there are no leaders. Each one is for himself.

34

Already we have the advantage that we are fighting not only for our lives and homes but for the immemorial cause of human liberty. But that is not enough. Provided we are united with our leaders in a common effort, real danger will never sap our morale. The greatest danger to our morale is unreal fear.

36

AD 408 094

FINAL REPORT

11 March 1963

Recovery and Decontamination Measures after Biological and Chemical Attack

This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

Contract OCD-OS-62-183

Prepared for
Office of Civil Defense
Department of Defense

by

Science Communication, Inc.
1079 Wisconsin Avenue, N. W.
Washington 7, D. C.

To plan for countermeasures against any weapons one must understand the problem—the nature, the potentials, and the limitations. This research project and the resultant final report were intended to bring together current information most applicable to civil defense. It was particularly intended for those who are responsible for planning preparatory, reclamation and countermeasures effort to minimize the damage from a BW/CW attack.

William J. Lacy
Project Coordinator
Postattack Research

Decontaminants

An important class of decontaminants comprises the common substances or natural influences such as time, air, earth, water, and fire.

Natural Effects

Biological agents are living organisms and tend to die off with time unless they are in a favorable environment with moisture, food, warmth, and other factors necessary for their survival. In addition, most biological organisms are very sensitive to the conditions of temperature and humidity -- and, particularly to the ultra-violet portion of sunlight. Adverse exposure to the elements -- air, sunlight, high temperature, low humidity -- is effective, in fact, against all biological agents except the spore forms of bacterial organisms.

It is generally assumed that in the vegetative form bacteria (as contrasted to the spore form) can persist for less than two hours during daytime and about eighteen hours at night. Since these short-lived bacteria are the most probable agents, outdoor decontamination is usually not called for unless the agent has been identified, either by laboratory tests or by the character of the disease, as one which forms spores or is otherwise known to be persistent.

Appraisal of Biological and Chemical Warfare Protection in the U.S. Field Army. Booz, Allen Applied Research, Inc., June 1961. AD 329 113, (SECRET).

Area-Coverage Capabilities of Bacteriological and Chemical Weapons (U). Tamplin, A.R., Rand Corporation, April 1962. AD 329 207, (SECRET).

Biological Decontamination. Asher, T.M., Naval Biological Laboratory, February 1954. AD 72 485, (SECRET).

Biological Problems Attendant Upon the Application of Bacteriological and Chemical Agents in Limited War (U). Tamplin, A.R., Rand Corporation, RM-2677, June 1961. AD 324 462, (SECRET).

Chemical and Biological Weapons Employment. Department of the Army Field Manual, FM 3-10, February 1962.

Community Reaction to an Accidental Chlorine Exposure - Task Sirocco. Segaloff, Louis, University of Pennsylvania, November 1961. AD 269 681.

Decontamination of Water Contaminated with VX. Lindsten, Don C. and Bauer, Virginia E., U.S. Army Engineer Research and Development Laboratories, Research Report 1630-RR, May 1960. AD 239 310.

Effects of Cooking and Baking Processes on the Sterilization of Food Contaminated with Bacterial Spores. Commissary Research Division, U.S. Naval Supply Research and Development Facility, Final Report Navy Project NT 002 024 (CR 53-89), 1953.

Evaluation of Standard and Modified Laundering Procedures as BW Decontamination Methods. Portner, Dorothy M., Mayo, Elizabeth C. and Surkiewicz, Bernard F., Biological Warfare Laboratories, Technical Memorandum 1-2, March 1959. AD 252 270L.

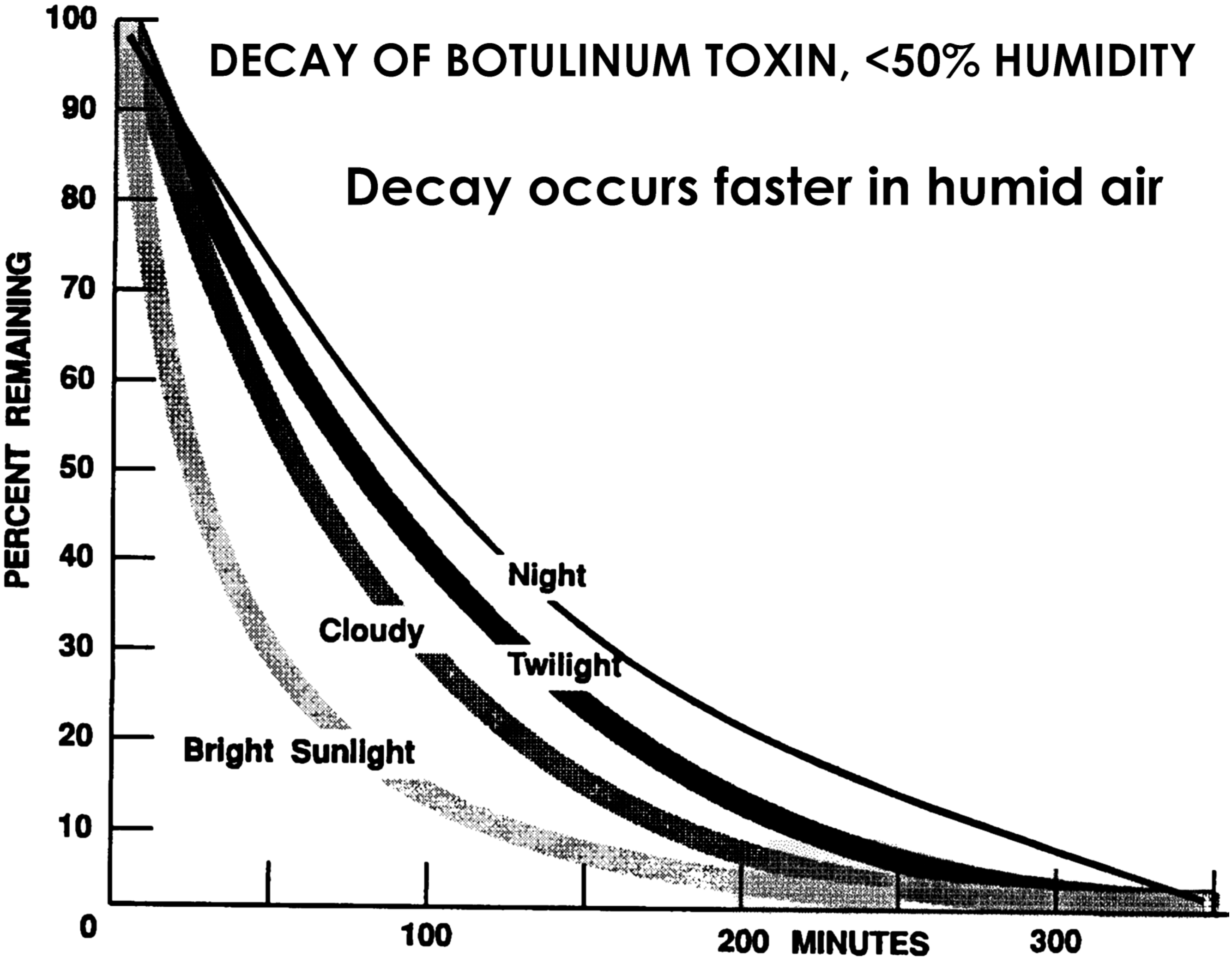
Field Purification of Water Contaminated by G Agents. Chemical Corps Medical Division Report No. 220, 1949. AD 212 449.

Field Tests of Protective Clothing Exposed to BW Aerosols. Chemical Corps Biological Laboratories, Special Report No. 112, August 1949.

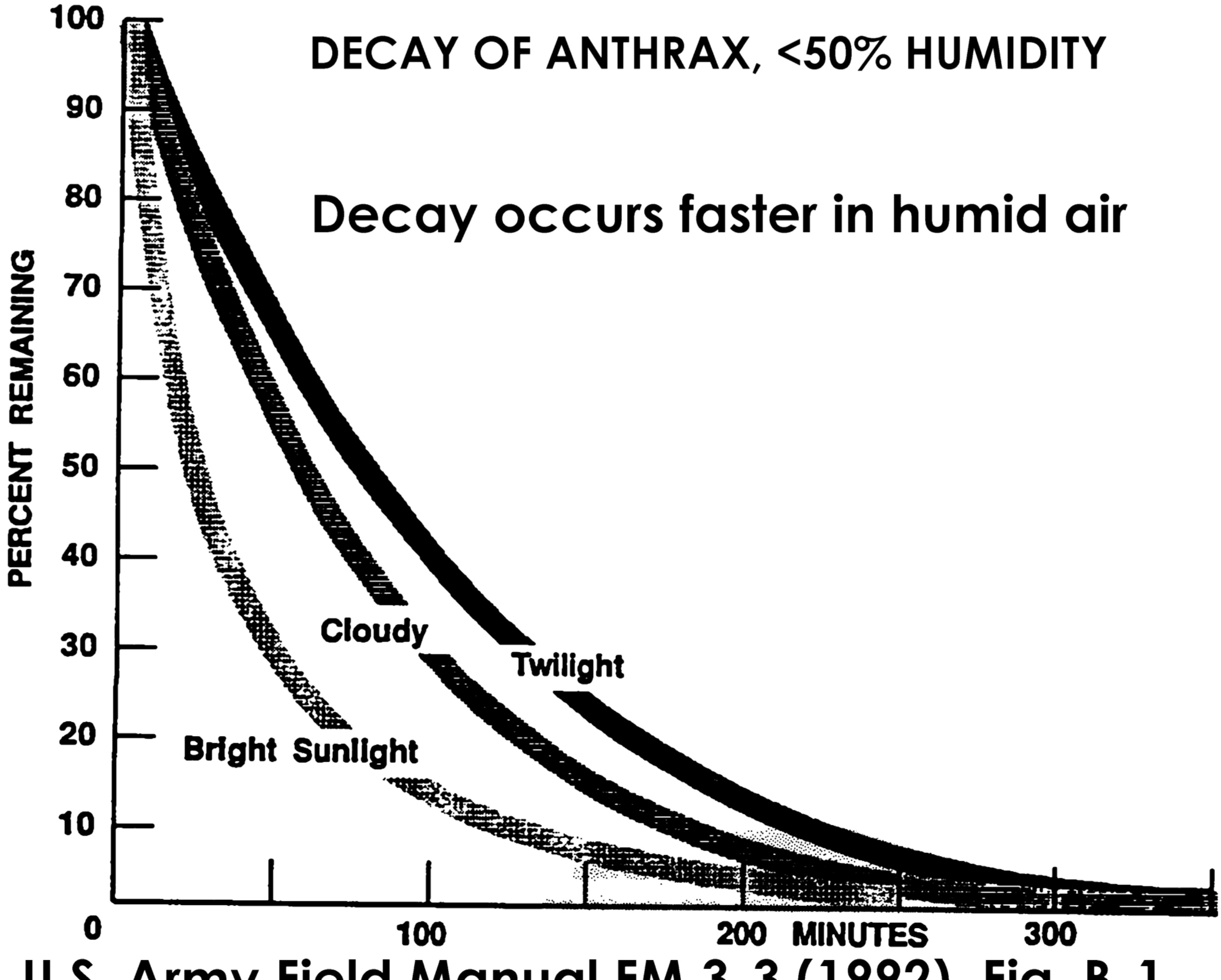
Possible Applications of Bacteriological Warfare to Public Water Supplies. Maloney, John R., Office of Naval Research, November 1959. AD 69 721, (CONFIDENTIAL).

Some Indications of Soviet Views on the Strategic Employment of CW/BW (U). Gouré, Leon, Rand Corporation, RM-2725, March 1961. (SECRET).

Studies on Insect Control (U). U.S. Army Engineer Research and Development Laboratories, Research Report 1656-RR, October 1960. AD 321 975, (CONFIDENTIAL).



U.S. Army Field Manual FM 3-3 (1992), Fig. B-3.



U.S. Army Field Manual FM 3-3 (1992), Fig. B-1.

Chemical and biological contamination avoidance, FM 3-3 (1992)

10 grams/square meter

TABLE 1-2. Chemical Agent Persistency in Hours on CARC Painted Surfaces.

Temperature C°	Temperature F°	GA/GF[1]	GB[2,3]	GD[2,3]	HD[1]	VX[2,3]
-30	-22	*	110.34	436.69	**	***
-20	-4	*	45.26	145.63	**	***
-10	14	*	20.09	54.11	**	***
0	32	*	9.44	22.07	**	***
10	50	1.42	4.70	9.78	12	1776
20	68	0.71	2.45	4.64	6.33	634
30	86	0.33	1.35	2.36	2.8	241
40	104	0.25	0.76	1.25	2	102
50	122	0.25	0.44	0.70	1	44
55	131	0.25	0.34	0.51	1	25

NOTE

1 For grassy terrain multiply the number in the chart by 0.4.
2 For grassy terrain multiply the number in the chart by 1.75.
3 For sandy terrain multiply the number in the chart by 4.5.
* Agent persistency time is less than 1 hour.
** Agent is in a frozen state and will not evaporate or decay.
*** Agent persistency time exceeds 2,000 hours.

COMPARATIVE VOLATILITY OF CHEMICAL WARFARE AGENTS

Agent	Volatility (mg/m^3) at 25°C
Hydrogen cyanide (HCN)	1,000,000
Sarin (GB)	22,000
Soman (GD)	3,900
Sulfur mustard	900
Tabun (GA)	610
Cyclosarin (GF)	580
VX	10
VR ("Russian VX")	9

Data source: US Departments of the Army, Navy, and Air Force. *Potential Military Chemical/Biological Agents and Compounds*. Washington, DC: Headquarters, DA, DN, DAF; December 12, 1990. Field Manual 3-9. Naval Facility Command P-467. Air Force Regulation 355-7.

TABLE 21-3

MANAGEMENT OF MILD TO MODERATE NERVE AGENT EXPOSURES

		Management			
		Antidotes*		Benzodiazepines (if neurological signs)	
Nerve Agents	**Symptoms**	**Age**	**Dose**	**Age**	**Dose**
• Tabun • Sarin • Cyclosarin • Soman • VX	• Localized sweating • Muscle fasciculations • Nausea • Vomiting • Weakness/floppiness • Dyspnea • Constricted pupils and blurred vision • Rhinorrhea • Excessive tears • Excessive salivation • Chest tightness • Stomach cramps • Tachycardia or bradycardia	Neonates and infants up to 6 months old	**Atropine** 0.05 mg/kg IM/IV/IO to max 4 mg or 0.25 mg AtroPen† and **2-PAM** 15 mg/kg IM or IV slowly to max 2 g/hr	Neonates	**Diazepam** 0.1–0.3 mg/kg/dose IV to a max dose of 2 mg, or **Lorazepam** 0.05 mg/kg slow IV
		Young children (6 months old–4 yrs old)	**Atropine** 0.05 mg/kg IM/IV/IO to max 4 mg or 0.5 mg AtroPen and **2-PAM** 25 mg/kg IM or IV slowly to max 2 g/hr	Young children (30 days old–5 yrs old)	**Diazepam** 0.05–0.3 mg/kg IV to a max of 5 mg/dose or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Older children (4–10 yrs old)	**Atropine** 0.05 mg/kg IV/IM/IO to max 4 mg or 1 mg AtroPen and **2-PAM** 25–50 mg/kg IM or IV slowly to max 2 g/hr	Children (≥ 5 yrs old)	**Diazepam** 0.05–0.3 mg/kg IV to a max of 10 mg/dose or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Adolescents (≥ 10 yrs old) and adults	**Atropine** 0.05 mg/kg IV/IM/IO to max 4 mg or 2 mg AtroPen and **2-PAM** 25–50 mg/kg IM or IV slowly to max 2 g/hr	Adolescents and adults	**Diazepam** 5–10 mg up to 30 mg in 8 hr period or **Lorazepam** 0.07 mg/kg slow IV not to exceed 4 mg

2-PAM: 2-pralidoxime
IM: intramuscular
IO: intraosseous
IV: intraveneous
PDH: Pediatrics Dosage Handbook
*In general, pralidoxime should be administered as soon as possible, no longer than 36 hours after the termination of exposure. Pralidoxime can be diluted to 300 mg/mL for ease of intramuscular administration. Maintenance infusion of 2-PAM at 10–20 mg/kg/hr (max 2 g/hr) has been described. Repeat atropine as needed every 5–10 minutes until pulmonary resistance improves, secretions resolve, or dyspnea decreases in a conscious patient. Hypoxia must be corrected as soon as possible.
†Meridian Medical Technologies Inc, Bristol, Tenn.
Data sources: (1) Rotenberg JS, Newmark J. Nerve agent attacks on children: diagnosis and management. *Pediatrics*. 2003;112:648–658. (2) Pralidoxime [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2002. (3) AtropPen (atropine autoinjector) [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2004. (4) Henretig FM, Cieslak TJ, Eitzen Jr EM. Medical progress: biological and chemical terrorism. *J Pediatr*. 2002;141(3):311–326. (5) Taketomo CK, Hodding JH, Kraus DM. *American Pharmacists Association: Pediatric Dosage Handbook*. 13th ed. Hudson, Ohio; Lexi-Comp Inc: 2006.

TABLE 21-4

MANAGEMENT OF SEVERE NERVE AGENT EXPOSURE

		Management			
		Antidotes*		**Benzodiazepines (if neurological signs)**	
Nerve Agents	**Severe Symptoms**	**Age**	**Dose**	**Age**	**Dose**
• Tabun • Sarin • Cyclosarin • Soman • VX	• Convulsions • Loss of consciousness • Apnea • Flaccid paralysis • Cardio-pulmonary arrest • Strange and confused behavior • Severe difficulty breathing • Involuntary urination and defecation	Neonates and infants up to 6 months old	**Atropine** 0.1 mg/kg IM/IV/IO or 3 doses of 0.25mg AtroPen† (administer in rapid succession) and **2-PAM** 25 mg/kg IM or IV slowly, or 1 Mark I† kit (atropine and 2-PAM) if no other options exist	Neonates	**Diazepam** 0.1–0.3 mg/kg/dose IV to a max dose of 2 mg, or **Lorazepam** 0.05 mg/kg slow IV
		Young children (6 months old–4 yrs old)	**Atropine** 0.1 mg/kg IV/IM/IO or 3 doses of 0.5mg AtroPen (administer in rapid succession) and **2-PAM** 25–50 mg/kg IM or IV slowly, or 1 Mark I kit (atropine and 2-PAM) if no other options exist	Young children (30 days old–5 yrs and adults	**Diazepam** 0.05–0.3 mg/kg IV to a max of 5 mg/dose, or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Older children (4–10 yrs old)	**Atropine** 0.1 mg/kg IV/IM/IO or 3 doses of 1mg AtroPen (administer in rapid succession) and **2-PAM** 25–50 mg/kg IM or IV slowly, 1 Mark I kit (atropine and 2-PAM) up to age 7, 2 Mark I kits for ages > 7–10 yrs	Children (≥ 5 yrs old)	**Diazepam** 0.05-0.3 mg/kg IV to a max of 10 mg/dose, or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Adolescents (≥ 10 yrs old) and adults	**Atropine** 6 mg IM or 3 doses of 2 mg AtroPen (administer in rapid succession) and **2-PAM** 1800 mg IV/IM/IO, or 2 Mark I kits (atropine and 2-PAM) up to age 14, 3 Mark I kits for ages ≥ 14 yrs	Adolescents and adults	**Diazepam** 5–10 mg up to 30 mg in 8-hr period, or **Lorazepam** 0.07 mg/kg slow IV not to exceed 4 mg

IM: intramuscular
IO: intraosseous
IV: intravenous

*In general, pralidoxime should be administered as soon as possible, no longer than 36 hours after the termination of exposure. Pralidoxime can be diluted to 300 mg/mL for ease of intramuscular administration. Maintenance infusion of 2-PAM at 10–20 mg/kg/hr (max 2 g/hr) has been described. Repeat atropine as needed every 5–10 min until pulmonary resistance improves, secretions resolve, or dyspnea decreases in a conscious patient. Hypoxia must be corrected as soon as possible. †Meridian Medical Technologies Inc, Bristol, Tenn.

Data sources: (1) Rotenberg JS, Newmark J. Nerve agent attacks on children: diagnosis and management. *Pediatrics*. 2003;112:648–658. (2) Pralidoxime [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2002. (3) AtroPen (atropine autoinjector) [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2004. (4) Henretig FM, Cieslak TJ, Eitzen Jr EM. Medical progress: biological and chemical terrorism. *J Pediatr*. 2002;141(3):311–326. (5) Taketomo CK, Hodding JH, Kraus DM. *American Pharmacists Association: Pediatric Dosage Handbook*. 13th ed. Hudson, Ohio: Lexi-Comp Inc; 2006.

French family at Marbache, Meurthe et Moselle, France, September 1918. Gas masks were compulsory in the village, due to nearby gas attacks. Photo is the frontispiece of the October 1921 reprint of Will Irwin's book "The Next War" (Dutton, N.Y., 19th printing Oct 1921; first published April 1921.)

J. Davidson Pratt, "Gas Defence from the Point of View of the Chemist" (Royal Institute of Chemistry, London, 1937): "... during the Great War, French and Flemish ... living in the forward areas came unscathed through big gas attacks by going into their houses, closing the doors - the windows were always closed in any case - and remaining there..."

London 1941 baby gas mask drill


Hand pumped
(asthmatic)
Baby's
Hospital patient's
Police
/warden
Civilian
Soldier's
until 1942
Small child's
(mickey mouse)

Breathe Freely !

THE TRUTH ABOUT POISON GAS

JAMES KENDALL

M.A., D.Sc., F.R.S.

Professor of Chemistry in the University of Edinburgh; formerly Lieutenant-Commander in the United States Naval Reserve, acting as Liaison Officer with Allied Services on Chemical Warfare

1938

CASUALTIES IN INITIAL GAS ATTACKS

Gas	*Date*	*Amount Used In Tons*	*Lethal Concentration **	*Non-fatal injuries*	*Deaths*
Chlorine	Apr. 22, 1915	168	5·6	15,000	5,000
Phosgene	Dec. 19, 1915	88	0·5	1,069	120
Mustard	July 12, 1917	125	0·15	2,490	87

(* mg/litre for 10 minutes exposure unprotected)

between September 15 and November 11, 1918, 2,000,000 rounds of gas shell, containing 4,000 tons of mustard gas, were fired against the advancing British troops; our losses therefrom were 540 killed and 24,363 injured. Gas defence had progressed to the point where it took nearly 8 tons of mustard gas to kill a single man !

The first salvo of gas shells often reaches the trenches before the occupants don their masks, whereas the Londoner will receive ample warning of the approaching danger.

The alarmist and the ultra-pacifist love to quote the fact that one ton of mustard gas is sufficient to kill 45,000,000 people. This would indeed be true if the 45,000,000 people all stood in a line with their tongues out waiting for the drops to be dabbed on, but they are hardly likely to be so obliging. One steam-roller would suffice to flatten out all the inhabitants of London if they lay down in rows in front of it, but nobody panics at the sight of a steam-roller.

11

EVER since the Armistice, three classes of writers have been deluging the long-suffering British public with lurid descriptions of their approaching extermination

These three classes are pure sensationalists, ultra-pacifists and military experts.

12 PANIC PALAVER

perpetrators of such articles may not recognize themselves that what they are writing is almost entirely imaginary, but they do want to get their manuscript accepted for the feature page of the *Daily Drivel* or the *Weekly Wail*. In order to do that, they must pile on the horrors thick, and they certainly do their best

The amount of damage done by such alarmists cannot be calculated, but it is undoubtedly very great.

poison gas has a much greater news value. It is still a new and mysterious form of warfare, it is something which people do not understand, and what they do not understand they can readily be made to fear.

13

The recent film *Things to Come*, in particular, has provided a picture of chemical warfare of the future which shows how simply and rapidly whole populations will be wiped out. Millions of people, perhaps, have been impressed by the authority and reputation of Mr. H. G. Wells into believing that this picture represents the plain truth.

17

EXHIBIT 'B' is the work of the ultra-pacifist. He abominates war and everything connected with war to such an extent that he paints a highly coloured picture of its horrors, in the most extreme Surrealistic style, with the object of frightening the public to the point where they will relinquish, in the hope of escaping war, even the right of self-defence. His motives may be praiseworthy, but his methods are to be deplored.

Tel. No.: VICtoria 6826

Any communication on the subject of this letter should be addressed to—

The Under Secretary of State,
Home Office (A.R.P. Dept.),
Horseferry House,
Thorney Street,
London, S.W.1.

and the following number quoted:—
701,602/109

HOME OFFICE,
Air Raid Precautions Dept.,
HORSEFERRY HOUSE,
THORNEY STREET,
LONDON, S.W.1.

31*st December*, 1937.

Sir,

Experiments in Anti-Gas Protection of Houses

I am directed by the Secretary of State to transmit, for the information of your Council, the annexed Report describing in detail the experiments to which reference was made by the Parliamentary Under Secretary of State in his speech on the second reading of the Air Raid Precautions Bill in the House of Commons on the 16th November.

The experiments were conducted by the Chemical Defence Research Department under the aegis of a special Sub-Committee of the Chemical Defence Committee. That Sub-Committee was composed of eminent experts not in Government employment, and included a number of distinguished University professors and scientists.

I am,
Sir,
Your obedient Servant,
R. R. Scott.

The Clerk of the County Council.
The Town Clerk.
The Clerk to the District Council.

Issued to all
County Councils
County Borough Councils (and the Corporation of the City of London)
Metropolitan Borough Councils
Municipal Borough Councils
Urban and Rural District Councils
in England and Wales

Copies sent for information to Chief Officers of Police in England and Wales.

PROTECTION AGAINST GAS

REPORT OF EXPERIMENTS CARRIED OUT BY THE CHEMICAL DEFENCE RESEARCH DEPARTMENT

Handbook No. 1 issued by the Air Raid Precautions Department of the Home Office describes the steps which the public are advised to take in order to protect themselves against the effects of any chemical warfare gases which might be employed by enemy aircraft in time of war.

The gist of these recommendations is:—

First, to go indoors.

Secondly, to arrange for the room into which you go to be made as gas-proof as possible.

Thirdly, to take with you the respirator which will have been issued to you.

Whilst it has never been claimed that any one of these steps by itself will make an individual completely safe, experiments and trials have shown that each of these measures is by itself of considerable value and that when all of them are adopted a very high degree of protection is obtained. An outline is given below of certain typical experiments which have been carried out.

These particular experiments were carried out with four different types of actual war gas. The first four experiments to be described will show the degree of protection that is obtained from each type of gas merely by going indoors and shutting the doors and windows.

As explained in Handbook No. 1*, a chemical warfare gas may be dropped from aircraft either as spray or in bombs. In the former case the liquid drops fall like rain, and it is obvious that by going indoors the public will avoid them. On the other hand, if gas bombs are dropped, people who have gone indoors will avoid being splashed by the chemical in the bomb, and even in an ordinary room they will receive some protection from the gas cloud. The amount of protection obtained in a house which has not been treated in any way can be gathered from the following experiments.

(a) *Protection obtained in a house which has not been treated in any way.*

The house employed was a gamekeeper's cottage with three rooms on the ground floor and three rooms upstairs. It had been unoccupied for about 15 years but was in a reasonable state of repair. It was to a large extent sheltered by belts of

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* A.R.P. Handbook No. 1, "Personal Protection against Gas", price 6d. (8d. post free): published by H.M. Stationery Office (see back page).

trees which reduced the strength of the wind in the vicinity of the cottage to about one-eighth of that in the open. In this respect therefore the location of the cottage resembled a house in a town. In one experiment over a ton of actual chlorine gas was released 20 yards from the house so that the wind carried it straight on to the unprotected room. A very strong gas cloud was thus maintained outside the house for about 40 minutes, during which time the gas gradually penetrated to the inside. A fire was burning in the hearth the whole time, and the only measures taken to exclude the gas consisted of closing the doors and windows in the normal way.

Human beings who occupied this unprotected room found that gas penetrated slowly into the room, and after about seven minutes is became necessary for them to put on their respirators. Had these men been outside the house, they would have been compelled to put on their respirators immediately, since otherwise the very intense gas cloud would have caused instantaneous incapacitation and ultimate death.

If the gas, which with its containers weighed about 2½ tons, had been released more quickly, the strength of the gas cloud would have been greater but the time during which the house was enveloped by it would have been correspondingly shorter.

It is important to appreciate properly the severity of this trial. The quantity of gas concentrated on this house could under practical conditions only be obtained by several large bombs dropping very close to the building. The period of exposure to the maximum effects of the gas was also many times longer than would normally be experienced under most practical conditions, since the initial cloud from a gas bomb soon begins to be diluted and dispersed by the action of even quite moderate winds. It is clear that conditions similar to those of the experiment are extremely severe, and are such as would be likely to occur very rarely indeed and to a very small number of houses.

It should also be noted that the cottage used in this experiment had no carpets or other floor coverings. Most of the gas which leaked in came through the spaces between the floor boards, and it is therefore clear that much less would have got into an ordinary room in which there was a carpet, linoleum, or a solid floor.

In another experiment the house was surrounded at a distance of 20 yards by large shallow trays which were filled with mustard gas, the trays being spaced a few yards apart. By this means the vapour given off by the mustard gas was carried on to the house no matter how the direction of the wind varied. As the weather at the time was not very warm, the conditions of the experiment were made more severe by producing a fine spray of mustard gas at a point 10 yards to windward of

the house so that the house was enveloped in the resultant cloud of mustard gas for a period of an hour. The cloud produced in this way was about a hundred times as strong as that caused by the evaporation of the mustard gas from the trays. Animals were placed in an unprotected room in the house and remained there during the spraying period and for a further 20 hours while the house was subjected to the vapour of mustard gas given off from the trays. Observations made upon the animals during the three subsequent days and also post mortem examination showed that none of them was seriously harmed by the mustard gas.

The third type of gas used was tear gas. In this experiment the same cottage was enveloped for an hour in an intense atmosphere of tear gas produced by spraying the gas into the air at a point 10 yards upwind of the house. Men who were stationed 200 yards downwind from the house and in the track of the gas cloud were incapacitated in about a minute, and in some cases in 20 seconds. On the other hand, men who occupied rooms in the house which had received no treatment beyond the closing of the windows and doors found no need to put on their respirators for the first 13 minutes. The tear gas gradually penetrated into these unprotected rooms, although after three-quarters of an hour the strength of the gas inside the house was still very much less than that outside.

In the fourth experiment the cottage was enveloped for 20 minutes in a dense cloud of arsenical smoke. Men occupying an unprotected room of the house found that the arsenical smoke penetrated into the room, but the strength of the cloud inside was much less than that outside. When Civilian respirators were worn in this room, complete protection was obtained. Men who were stationed 200 yards downwind of the house and in the path of the gas cloud were rapidly affected, but when they wore Civilian respirators no effects were felt.

The above four examples clearly demonstrate that, apart from the protection which a house provides against falling airplane spray, some measure of protection is afforded even by an ordinary unprotected room against gas clouds such as are produced by bombs close to the building.

(b) *Protection afforded by a house treated in accordance with Air Raid Precautions Handbook No. 1.*

A brief account will now be given of four further experiments with the same four war gases in order to illustrate the added protection which can be obtained by treating a room in accordance with the instructions given in Air Raid Precautions Handbook No. 1. These experiments were also conducted with the cottage already mentioned. The room selected for treatment was situated on the ground floor on the windward side

of the house so that it was subjected to the full effect of the gas and the wind. It measured about 12 feet square. The Air Raid Precautions instructions for excluding gas were carried out by unskilled men, the official procedure being rigidly followed. As the house was not provided with carpets or other floor covering, it became necessary to seal up the joints between the boards over the whole of the floor of the selected room. This was done by pasting strips of paper along the joints between the floor boards. Some of these strips became displaced by the boots of the men who were inside the room, and an appreciable leakage of gas into the room undoubtedly occurred due to this cause. Two tons of chlorine were released 20 yards from the house, the time of emission being an hour. Animals were placed in the house, some in the " gas protected " room and others in rooms which had received no such treatment. The latter set of animals were killed by the gas which penetrated into the unprotected rooms under these very severe conditions. The animals in the " gas protected " room, however, were unaffected and remained normal, notwithstanding the severity of the trial.

An experiment with mustard gas, similar to that already described, was also carried out after the ground floor room on the windward side of the house had been treated in accordance with the Air Raid Precautions Department's procedure. Animals were placed in the room, which was then subjected to the same exposure of mustard gas spray and vapour as before. At the end of 20 hours the animals were removed and a most thorough examination of them showed no evidence of the effects of the gas at all. Animals placed outside the house during the first hour of the experiment were, of course, very seriously affected. The amount of mustard gas penetrating into the room was also measured by chemical methods and it was found that the amount of gas inside the room was so small that a man could have remained there for the whole 20 hours without its being necessary for him to wear a respirator and without any subsequent ill-effects.

The experiment with tear gas previously described was also performed against the " gas protected " room. A number of men occupied this room and found they were able to remain there without its being necessary for them to put on their respirators at any time during the hours that this very severe experiment lasted.

An experiment with arsenical smoke, similar to that already described, was also carried out against the " gas protected " room. The occupants found that the arsenical smoke penetrated the room to an extent which caused some irritation of the nose and throat and eventually rendered the wearing of respirators desirable to ensure comfort. After putting on the respirator, no

discomfort was felt throughout the remainder of the experiment. Men who left the " gas protected " room wearing their Civilian respirators were able to traverse the densest part of the cloud without discomfort. Under these severe conditions the presence of the arsenical smoke could be detected, but the effects were insignificant.

It is important to appreciate fully the severity of the conditions imposed in the two trials with arsenical smoke. A very high concentration of the irritant smoke was maintained around the house for 20 minutes. Under practical conditions such a high concentration could be produced only by a large and efficiently designed bomb falling close to the building, and then only for a short period. The conditions of the trials were therefore extremely severe and represent a situation which would only rarely be met, and in which only a small number of houses would be involved.

From this second series of experiments it will be seen that treating a room in accordance with the recommendations of the Air Raid Precautions Department does reduce very considerably the amount of gas penetrating into the room, and that a room so treated is correspondingly safer than a room which has received no such treatment.

Indeed, in the case of the experiments with mustard gas and tear gas, the amount of gas which was able to penetrate into the gas protected room was so small that no further measures of protection were necessary.

In the experiment with chlorine, although the amount of gas which entered the treated room was insufficient to injure the animals, human beings who occupied the room during this extremely severe test could smell the gas. They were provided with Civilian respirators, and they found that by putting these respirators on they were completely protected against every trace of gas. Some of these individuals then left the " gas protected " room, passed out of the house, and traversed the lethal cloud of gas which enveloped it. Although they deliberately stood in the densest part of the cloud for some minutes, no trace of the gas passed through their respirators.

Similarly the experiments with arsenical smoke show that although, under the most severe conditions, the cloud may penetrate into the " gas protected " room in sufficient quantity to be detected, or even to cause some irritation, the effects are materially reduced in a room so treated. It is also demonstrated that wearing a Civilian respirator affords complete protection against any smoke which may gain access to the room. The respirator also enabled individuals to pass through an extremely dense cloud of arsenical smoke in complete safety.

The experiments which have been outlined in this statement were purposely designed to represent the most severe conditions likely to be met. The results all combine to show that if the instructions given in Air Raid Precautions Handbook No. 1 are carried out a very high standard of protection is obtained. With regard to the first precaution it has been shown that going indoors and closing the doors and windows affords some measure of protection, even though the room occupied has not been specially prepared. In these circumstances there is ample time to put on the respirator at leisure if this should be necessary. If the second precaution of rendering the room as gas-proof as possible has been carried out, then the occupants will normally be able to remain in complete safety and comfort without further protection. Under the most severe conditions sufficient gas may penetrate such protected rooms to be recognized or even to cause slight irritation. When this occurs the respirator can be put on though in many cases this will be as a matter of convenience and extra precaution rather than real necessity. With regard to the Civilian respirator it has been shown that this will, in conjunction with the above precautions, provide complete safety for any period for which it is likely to be required. It has further been demonstrated that this respirator will enable the wearer to reach a place of safety even if he should for a time be exposed to the most dangerous situation—for example if he is caught out of doors in a gas cloud, or if his gas-protected room becomes damaged and he is compelled to seek shelter elsewhere.

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SCIENTIFIC INTELLIGENCE OFFICERS'

OPERATIONAL NOTES

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Notes on BW and CW

General

Toxicological warfare can consist either of a tactical attack with chemical weapons producing an immediate incapacitating effect, or of a strategic attack with biological weapons which have a delayed effect.

The new Civilian Respirator (C7), with pneumatic tube face fitting which is comfortable for long periods of wearing, affords excellent protection against BW and CW attacks.

BW

In attacks on populations, since the airborne hazard is the main one, only agents of high infectivity and high virulence (i.e. a small number of organisms required to produce infection and cause severe illness), combined with viability for many hours in the atmosphere, are likely to prove effective.

Some representative pathogenic micro-organisms

Bacterial	Anthrax	(lethal, very persistent spores but relatively low infectivity)
	Brucellosis	(incapacitating)
	Tularaemia	(incapacitating or lethal)
	* Rickettsial	Q fever (like typhus)
	* Viruses	Encephalomyelitis (brain fever)
		Smallpox (epidemic)

ON23:2

Personal protection

Respirators and discardible covers for head and body may be used. Extreme personal cleanliness is necessary. Total dosage can be reduced very considerably in a closed room in a house by sealing window cracks and door gaps before the arrival of contamination and ventilating the room fully as soon as it has passed.

Decontamination

Where appropriate the following measures may be taken:-

(a) weathering for a few days will destroy most bacterial agents other than anthrax spores
(b) use of bleach solution
(c) scattering petrol and firing it on open contaminated ground.

CW

Mustard gas and anticholinesterase agents (persistent and non-persistent nerve gases) are the CW agents most likely to be encountered in a tactical battle.

Building/ Vehicle Type	Air Exchange Rate (ACH)	Time Building Is Exposed (hr.)	Time of Occupancy from Cloud Arrival (hr.)	Shielding Factor
Residential Building (Windows Closed)[1]	0.53	0.25	0.25	15.8
	0.08-3.24	0.25	0.25	100.7-3.2
Residential Building (Windows Open)[1]	6.4	0.25	0.25	2.0
Nonresidential Building[1]	1.285	0.25	0.25	6.9
	0.3-4.1	0.25	0.25	27.3-2.7
Vehicle[1]	36	0.25	0.25	1.1
Mass-Transit Vehicle[1]	1.8-5.6	0.25	0.25	5.1-2.2
Stationary Automobile[2]:				
Windows Closed/No Ventilation	1.0-3.0	0.25	0.25	8.7-3.4
Windows Closed/Fan On Recirculation	1.8-3.7	0.25	0.25	5.1-2.9
Windows Open/No Ventilation	13.3-26.1	0.25	0.25	1.4-1.2
Windows Open/Fan On Fresh Air	36.2-47.5	0.25	0.25	1.1

1 Ted Johnson, A Guide to Selected Algorithms, Distributions, and Databases used in Exposure Models Developed by the Office of Air Quality Planning and Standards (Chapel Hill, NC: TRJ Environmental, Inc., 22 May 2002), http://www.epa.gov/ttn/fera/data/human/report052202.pdf. Accessed 8 January 2008.

2 J. H. Park et al., "Measurement of Air Exchange Rate of Stationary Vehicles and Estimation of In-Vehicle Exposure," Journal of Exposure Analysis & Environmental Epidemiology 8, no. 1 (January–March 1998):65-78.

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OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

ORNL/TM-10423

Technical Options for Protecting Civilians from Toxic Vapors and Gases

C. V. Chester

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Office of Program Manager
for
CHEMICAL MUNITIONS
Aberdeen Proving Grounds, Maryland

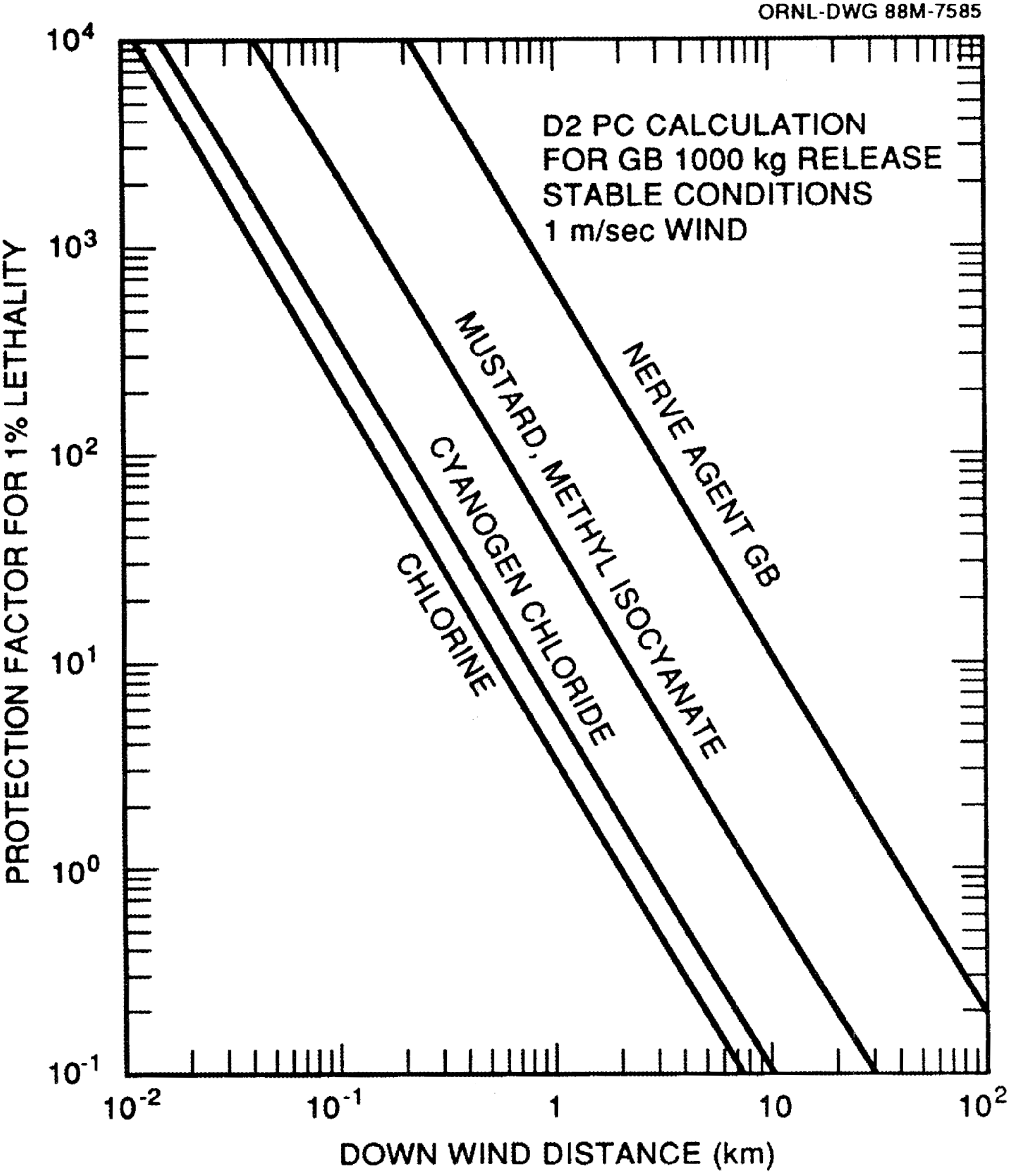

Fig. 1 Dose vs Downwind Distance for Some Very Toxic Gases

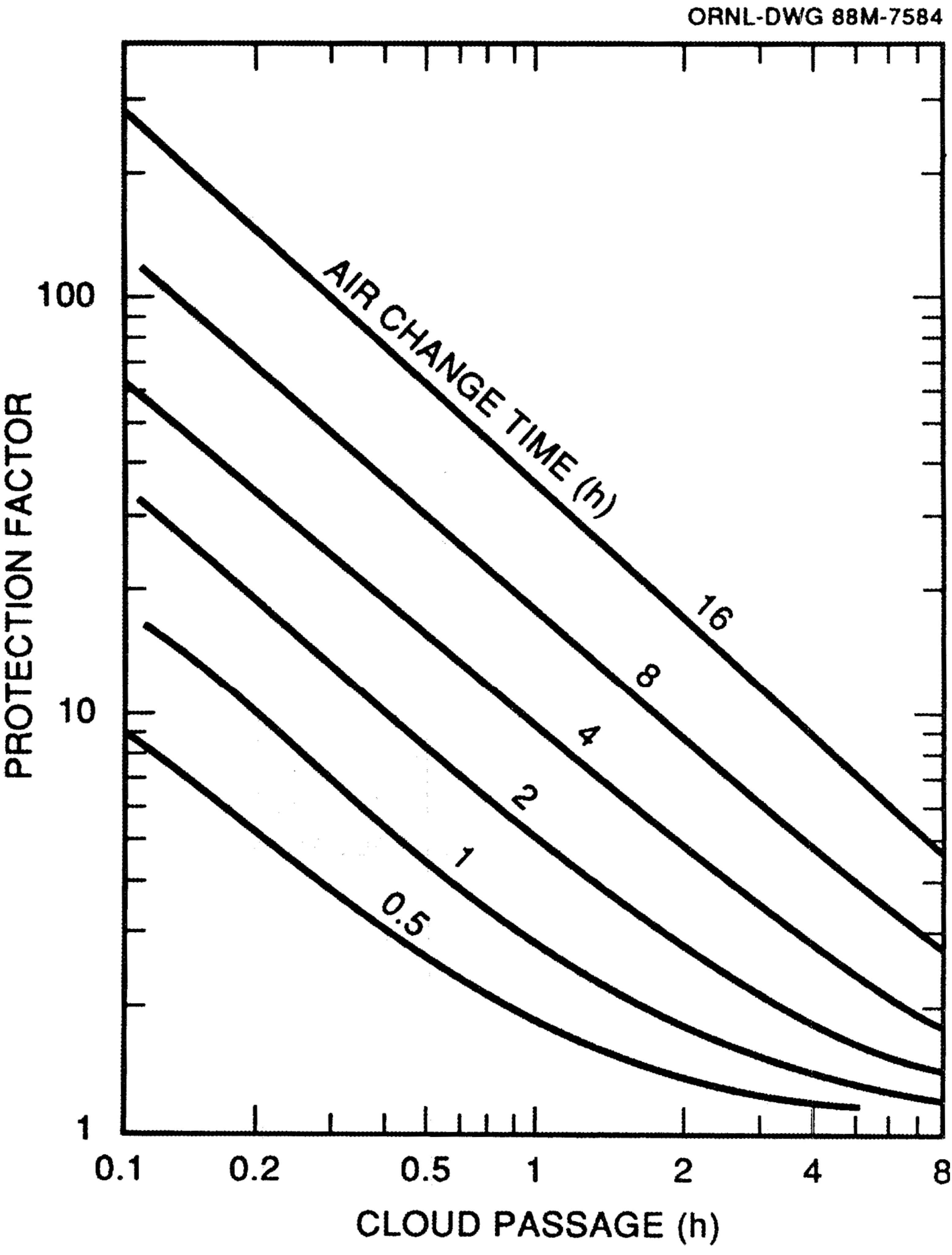

Fig. 2 Protection Factor of Leaky Enclosures

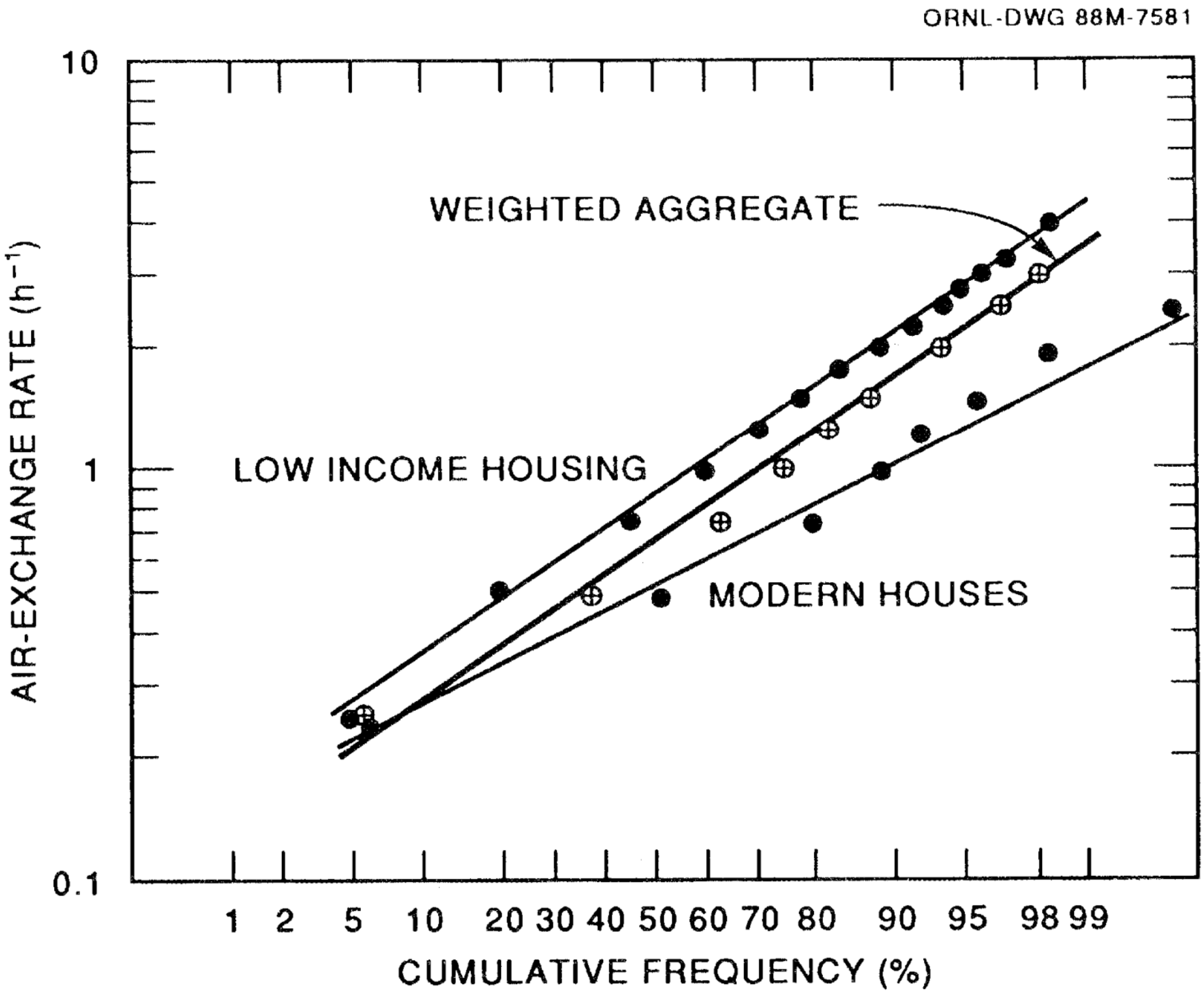

Fig. 3 Infiltration Rates of American Residences

ORNL/TM-2001/154

Energy Division

Will Duct Tape and Plastic Really Work? Issues Related To Expedient Shelter-In-Place

John H. Sorensen
Barbara M. Vogt

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Although vapors, aerosols, and liquids cannot permeate glass windows or door panes, the amount of possible air filtration through the seals of the panes into frames could be significant, especially if frames are wood or other substance subject to expansion and contraction. To adequately seal the frames with tape could be difficult or impractical. For this reason, it has been suggested that pieces of heavy plastic sheeting larger than the window be used to cover the entire window, including the inside framing, and sealed in place with duct or other appropriate adhesive tape applied to the surrounding wall.

Another possible strategy would be to use shrink-wrap plastic often used in weatherization efforts in older houses. Shrink-wrap commonly comes in a 6 mil (0.006-in.) thickness and is adhered around the frame with double-faced tape and then heated with a hair dryer to achieve a tight fit. This would likely be more expensive than plastic sheeting and would require greater time and effort to install. Because double-faced tape has not been challenged with chemical warfare agents, another option is to use duct tape to adhere shrink-wrap to the walls. Currently, we do not recommend using shrink-wrap plastics because of the lack of information on its suitability and performance.

3. WHY WERE THESE MATERIALS CHOSEN?

Duct tape and plastic sheeting (polyethylene) were chosen because of their ability to effectively reduce infiltration and for their resistance to permeation from chemical warfare agents.

3.1 DUCT TAPE PERMEABILITY

Work on the effectiveness of expedient protection against chemical warfare agent simulants was conducted as part of a study on chemical protective clothing materials (Pal et al. 1993). Materials included a variety of chemical resistant fabrics and duct tape of 10 mil (0.01-in.) thickness. The materials were subject to liquid challenges by the simulants DIMP (a GB simulant), DMMP (a VX simulant), MAL (an organoposphorous pesticide), and DBS (a mustard simulant). The authors note that simulants should behave similarly to live agents in permeating the materials; they also note that this should be confirmed with the unitary agents. The study concluded that “duct tape exhibits reasonable resistance to permeation by the 4 simulants, although its resistance to DIMP (210 min) and DMMP (210 min) is not as good as its resistance to MAL (>24 h) and DBS (> 7 h). Due to its wide availability, duct tape appears to be a useful expedient material to provide at least a temporary seal against permeation by the agents” (Pal et al. 1993, p. 140).

3.2 PLASTIC SHEETING PERMEABILITY

Tests of the permeability of plastic sheeting (polyethylene) challenged with live chemical warfare agents were conducted at the Chemical Defense Establishment in Porton Down, England in 1970 (NATO 1983, p. 133). Agents tested included H and VX, but not GB. Four types of polyethylene of varying thickness were tested: 2.5, 4, 10 and 20 mil (0.0025, 0.004 in., 0.01 in., and 0.02 in.). The results of these tests are shown in Table 1.

Table 1: Permeability of plastic sheeting to liquid agent

	Breakthrough time (h)	
Thickness	VX	H
0.0025	3	0.3
0.004	7	0.4
0.01	30	2
0.02	48	7

Source: NATO 1983, p. 136.

The data shows that at thickness of 10 mil or greater, the plastic sheeting provided a good barrier for withstanding liquid agent challenges, offering better protection against VX than for H. Because the greatest challenge is from a liquid agent, the time to permeate the sheeting will be longer for aerosols and still longer for vapors, but the exact relationship is unknown due to a lack of test data.

NATO Civil Defense Committee 1983. *NATO Handbook on Standards and Rules for the Protection of the Civil Population Against Chemical Toxic Agents*, AC/23-D/680, 2nd rev.

Pal, T., G.Griffin, G. Miller, A. Watson, M. Doherty, and T. Vo-Dinh. 1993. “Permeation Measurements of Chemical Agent Simulants Through Protective Clothing Materials,” *J. Haz. Mat.* **33**:123-141.

FM 3-10

DEPARTMENT OF THE ARMY FIELD MANUAL

CHEMICAL AND BIOLOGICAL WEAPONS EMPLOYMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY
FEBRUARY 1962

Line	1 Munition	2 Agent	3 Delivery system	4 User	5 Employment data (a) Range (Meters) (1) Maximum	(2) Minimum	(b) Error	(c) Fuze (Capability)
1	Shell, M2A1	HD	4.2-inch Mortar	US ARMY USMC	3,930	180	←Obtain from delivery unit or appropriate firing tables→	M8PD
2	Shell, M360	GB	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11,140	862		M508PD
3	Shell, M60	HD	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11,140			M51A5PD
4	Shell, M121	GB	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			M508PD
5	Shell, M110	HD	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			M51A5PD
6	Shell, T__(M121)	VX	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			T76E6VT [1]
7	Shell, M122	GB	155-mm Gun, M2, M53	USMC	23,500			M508PD
8	Shell, M104	HD	155-mm Gun, M2, M53	USMC				M51A5PD
9	Shell, Gas, 175-mm	GB	M107 Gun (SP)	US ARMY	31,500	180		
10	Shell, Gas, 175-mm	VX	M107 Gun (SP)	US ARMY	31,500	180		VT-M514A1
11	Shell, T174	GB	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC	16,930			M51A5PD
12	Shell, T174	VX	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC.	16,930			T2061VT
13	Rocket, M55, 115-mm (BOLT)	GB	Launcher, M91	US ARMY USMC.	10,970	2,740		M417PD
14	Rocket, M55, 115-mm (BOLT)	VX	Launcher, M91	US ARMY USMC.	10,970	2,740		T2061VT
15	Warhead, M79, 762-mm (HONEST JOHN).	GB	Rocket, M31A1C Launcher, M386.	US ARMY USMC.	24,960	8,500		T2075 Mech Time
16	Warhead, E19R2, 762-mm (HONEST JOHN).	GB	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830	8,500		T2075 Mech Time
17	Warhead, E19R2, 762-mm (HONEST JOHN).	VX	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830	8,500		T2075 Mech Time
18	Warhead, E20, 318-mm (LITTLE JOHN).	GB	Rocket, XM51 Launcher, XM80.	US ARMY USMC.	18,290	3,200 [1]		T2075 Mech Time
19	Warhead, E21, (SERGEANT)	GB	Rocket, Launcher	US ARMY	139 km	50 km	304m	Preset Radar
20	Warhead, E21, (SERGEANT)	VX	Rocket, Launcher	US ARMY	139 km	50 km	304m	Preset Radar
21	Bomb, M34A1, 1000-lb, Cluster	GB	Fighter, Bomber	USAF	Range of Aircraft.		←Obtain from delivery unit→	M152E3 Mech Time
22	Bomb, MC-1, 750-lb	GB	Fighter, Bomber	USAF	Range of Aircraft.			M905BD
23	Projectile, 5"/38, MK53, MOD O	GB	5-inch Gun	US NAVY	16,450			MK29MOD3PD
24	Projectile, 5"/54, MK54, MOD O	GB	5-inch Gun	US NAVY	19,200			MK30MOD3PD
25	Warhead, Rocket, 5" MK40, MOD O.	GB	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY	4,200			MK30MOD3PD
26	Warhead, Rocket, 5", MK40, MOD O.	HD	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY	4,200			MK30MOD3PD
27	Bomb, MK94, MOD O	GB	Fighter, Bomber	US NAVY	Range of Aircraft.			AN-M103A1ND M195 BD (IMPACT).
28	Bomb, M70A1	HD	Fighter, Bomber	US NAVY	Range of Aircraft.			AN-M158ND (IMPACT).
29	Mine, Land, Chemical, M23	VX	N/A	US ARMY	N/A	N/A	N/A	
30	Mine, Land, Chemical, One-Gallon.	HD	N/A	US ARMY	N/A	N/A	N/A	

See notes at end of figure.

Figure 5. Chemical munitions and delivery systems.

5 Employment data—Continued						6 Functioning and physical characteristics of CML munitions				
(d) Time for delivery		(e)	(f)	(g)	(h)	(a)	(b)	(c)	(d)	(e)
(1) Preplanned	(2) Target of opportunity	Organization	Rate of fire per weapon	Height of burst	Diameter (meters) of impact area (single rd) [2]	Weight of munition (kg)	Weight of agent (kg)	Effective weight of agent (kg) [3]	Functioning efficiency of munition (percent)	Agent dissemination efficiency
------	------	6 Mort/Plt 8 Mort/Btry	30 Rds/2 min 105 Rds/15 min	GND	16	10.8	2.72	------	99	
------	1–3 min	6 How/Btry	6 Rds/½ min 18 Rds/4 min	GND	27	16.1	.739	------	99	
------	1–3 min	6 How/Btry	6 Rds/½ min 18 Rds/4 min	GND	11	15.2	1.22	------	99	
------	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	GND	49	45.9	2.95	------	99	
------	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	GND	20	42.0	4.4	------	99	
------	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	20m [1]	------	45.9	2.95	------	99	
------	1–5 min	4 Gun/Btry	2 Rds/½ min 8 Rds/4 min	GND	49	45.9	2.95	------	99	
------	1–5 min	4 Gun/Btry	2 Rds/½ min 8 Rds/4 min	GND	22	43.0	5.31	------	------	
		4 Gun/Btry	------	GND	------	66.8	6.68	------	------	
------	------	4 Gun/Btry	------	GND	------	66.8	6.04	------	------	
------	½–6 hr	4 How/Btry	6 Rds/4 min 10 Rds/10 min	GND	76	97.0	7.12	------	99	
------	½–6 hr	4 How/Btry	6 Rds/4 min 10 Rds/10 min.	20m [1]	------	97.0	7.12	------	99	
------	30 min	36 Lchr/Bn	45 Rkt/Lchr/15 sec.	GND	46	26.4	4.80	------	99	
------	30 min	36 Lchr/Bn	45 Rkt/Lchr/15 sec.	20m [1]	------	26.2	4.54	------	99	
------	15 min	2 Lchr/Bn	2/Hr	Variable	Variable	737	177.5	104.8	95	62 percent.
------	15 min	2 Lchr/Btry	2/Hr	Variable	Variable	568	210	171	95	86 percent.
------	15 min	2 Lchr/Btry	2/Hr	Variable	Variable	568	210			
------	15 min	4 Lchr/Btry	2/Hr	Variable	Variable	119	30			
15 min	120 min	4 Lchr/Bn	2/Day	Intervals of 1,524m.	Variable	744	190			
15 min	120 min	4 Lchr/Bn	2/Day	Intervals of 1,524m.	Variable	744	190			
------	15 min +flight time.	------	2–6/Ftr 4–18/Bmbr.	Variable	170	513	89.6	------	90	
------	15 min +flight time.	------	2–6/Ftr 4–27/Bmbr.	GND	127	322	99.9			
------	------	------	------	GND	35	25.1	1.47			
------	------	------	------	GND	40	29.1	2.02			
------	------	------	48 Rkt/Lchr/ 1 min	GND	49	22.9	2.18			
------	------	------	48 Rkt/Lchr/ 1 min	GND	------	------	------			
------	------	------	------	GND	90	222	49.8			
------	------	------	------	GND	29	58.0	272			
------	------	------	------	------	------	10.50	5.23			
------	------	------	------	------	------	5.45	4.50			

[1] Estimated.
[2] Instantaneous agent area coverage 30 seconds after detonation.
[3] Values are the product of values given in columns 6(*b*), 6(*d*), and 6(*e*). Since values for 6(*e*) are not available, values for 6 (*c*)cannot be computed at this time.

Figure 5.—Continued

Agent—GB.
Wind speed—5 knots (approx 9 km/hr).
Temperature gradient—inversion.
Temperature—60° F. (15.5° C.).
Terrain—open, level, scattered vegetation.
Precipitation—none.
Time limitations on the delivery of agent on target—4 minutes or less.
Casualty level desired—20 percent.

Find: Whether or not the mission can be fired with a 105-mm howitzer battery.

Solution:

(*a*) Using figure 11, convert 20 percent casualties among protected personnel to the corresponding casualty level among unprotected personnel. This is 80 percent.

(*b*) Using the "GB (over 30-sec attack)" column of figure 12, determine the total effects components to be 3.21 as follows:

Inversion	1. 09
Wind speed, 9 km/hr	1. 00
Temperature, 60° F. (15.5° C.)	. 12
Open terrain	. 30
No precipitation	. 70
	3. 21

(*c*) Using figure 13, place a hairline between 80 percent on the percent casualties scale and 12 hectares on the target area scale. On the point of intersection on the reference line, pivot the hairline until it intersects 3.21 on the effects components scale. On the munitions expenditure scale, read 12 as the number of 155-mm equivalents required.

(*d*) To find the number of 105-mm rounds required to fire the mission, multiply 12 by a factor of four (obtain this factor from figure 8); the product is 48 rounds.

(*e*) From figure 9, it is evident that one battery of six howitzers can easily fire the mission if no shift of fires is required. Since the target is twice as large as the dispersion pattern of a 105-mm battery (par. 31*c*(3)(*c*) and 41*d*), a shift of fires should be made. Figure 9 gives a time of 30 seconds for shifting of fires. On this basis the battery could fire twenty-four rounds on half the target in a little less than 30 seconds, take 30 seconds to shift fires, and have ample time to deliver the remaining twenty-four rounds on the other half of the target. The firing should be completed in less than 2 minutes.

Munition	Munition expressed in terms of 155-mm chemical equivalents		
	GB	VX	HD
155-mm Shell	1	1	1
105-mm Shell	0. 25	--------	0. 28
8-inch Shell	2. 40	2. 17	--------
4.2-inch Mortar Shell	--------	--------	. 62
175-mm Shell	2. 1	2. 1	--------
M55 Rocket	1. 6	1. 6	--------
M79 Warhead—HONEST JOHN	60	--------	--------
E19R2 Warhead—HONEST JOHN	71	71	--------
LITTLE JOHN	10	10	--------
SERGEANT	65	65	--------
M34A1 1000-lb Cluster	30	--------	--------
MC1 750-lb Bomb	35	--------	--------
5″/38 Gas Projectile (Navy)	. 50	--------	--------
5″/54 Gas Projectile (Navy)	. 68	--------	--------
5″ Gas Rocket (Navy)	. 74	--------	--------
500-lb Gas Bomb	17	--------	--------
115-lb Gas Bomb (Navy)	--------	--------	6. 2

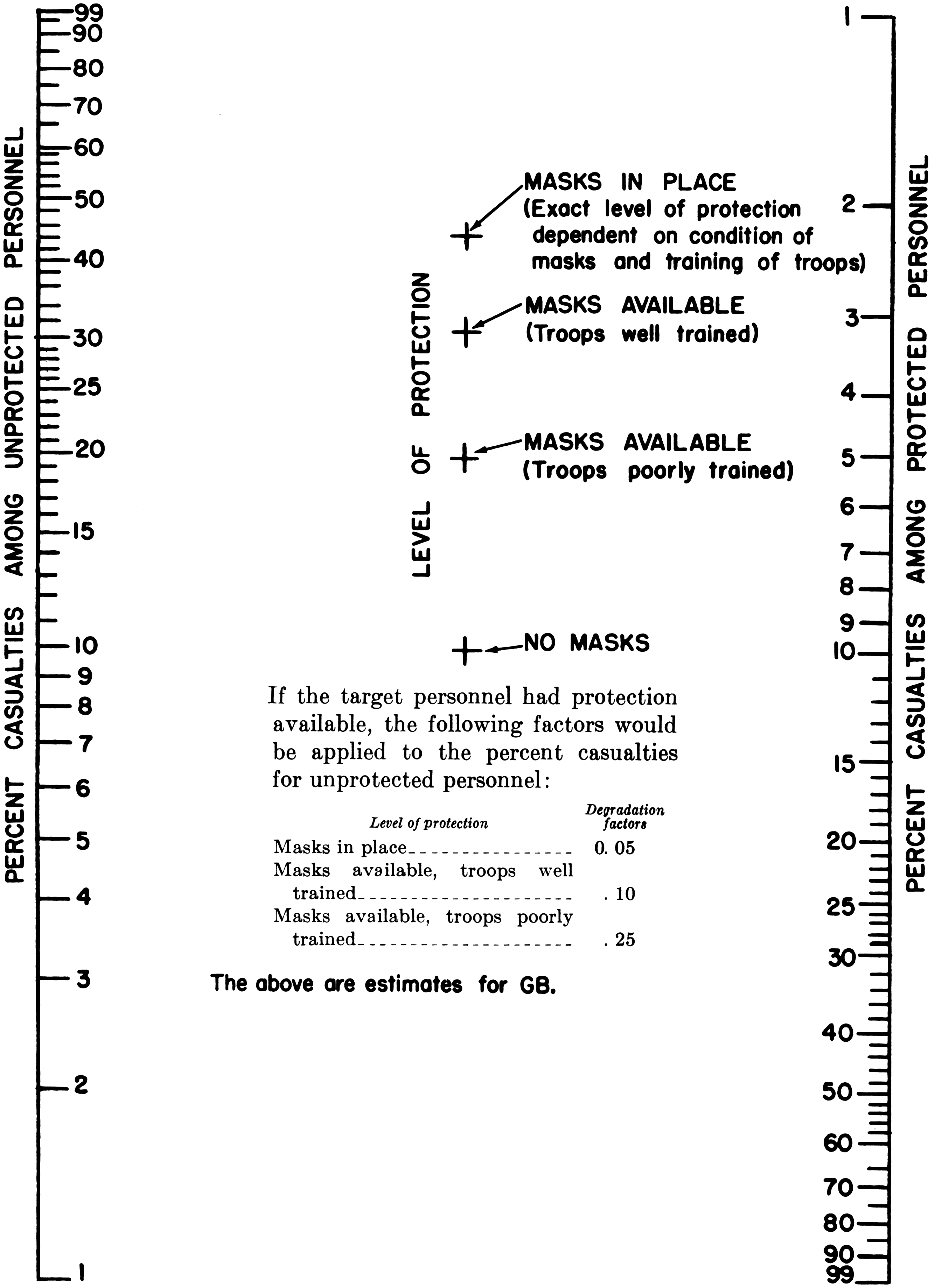
Figure 7. Munitions expressed in terms of 155-mm chemical equivalents. (The figures given are an estimate of the number of 155-mm howitzer rounds required to give the same effect as one round of the specified munition. Dissemination efficiency has not been considered.)

Munition	Conversion factor		
	GB	VX	HD
155-mm Shell	1	1	1
105-mm Shell	4	--------	3. 6
8-inch Shell	0. 41	0. 45	--------
4.2-inch Mortar Shell	--------	--------	1. 61
175-mm Shell	. 48	. 48	--------
M55 Rocket	. 61	. 61	--------
M79 Warhead—HONEST JOHN	. 017	--------	--------
E19R2 Warhead—HONEST JOHN	. 014	. 014	--------
LITTLE JOHN	. 098	. 098	--------
SERGEANT	. 016	. 016	--------
M34A1 1000-lb Cluster	. 033	--------	--------
MC1 750-lb Bomb	. 029	--------	--------
5″/38 Gas Projectile (Navy)	2. 00	--------	--------
5″/54 Gas Projectile (Navy)	1. 46	--------	--------
5″ Gas Rocket (Navy)	1. 35	--------	--------
500-lb Gas Bomb	. 059	--------	--------
115-lb Gas Bomb (Navy)	--------	--------	. 164

Figure 8. Conversion factors for converting 155-mm munitions to other munitions.

Weapon	Maximum rate (rounds)	Rates of fire for chemical fire missions without shifting or relaying of the piece (rounds)					Estimated time to shift fires
	30 sec	1 min	2 min	4 min	10 min	15 min	
105-mm Howitzer	6	10	14	18	40	60	30 sec
155-mm Howitzer	3	5	7	12	30	40	30 sec
155-mm Gun	2	4	6	8	12	18	60 sec
8-inch Howitzer	1	2	3	6	10	15	60 sec
4.2-inch Mortar	10	16	30 (max)	50	80	105	30 sec
M91 Launcher (M55 Rocket)	45 (15 sec)	Launcher must relocate after firing each ripple.					

Figure 9. Approximate rates of fire for division cannon artillery, mortars, and multiple rockets firing chemical rounds. (Rates of fire for other weapons are given in figure 5.)



If the target personnel had protection available, the following factors would be applied to the percent casualties for unprotected personnel:

Level of protection	*Degradation factors*
Masks in place	0. 05
Masks available, troops well trained	. 10
Masks available, troops poorly trained	. 25

The above are estimates for GB.

Figure 11. Nomogram for conversion of percent GB casualties for protection of personnel in the target area.

Meteorological and terrain conditions	Effects components			
	GB [2] (surprise attack)	GB (over 30-sec attack)	VX	HD
1. *Temperature Gradient*				
Inversion	0. 67	1. 09	1. 89	0. 69
Neutral	. 57	. 69	1. 89	. 54
Lapse	. 30	. 09	1. 89	. 32
2. *Wind Speed (km/hr)*				
0 to 5	. 20	1. 30	0	. 87
6 to 10	. 50	1. 00	0	. 70
11 to 16	. 70	. 70	0	. 60
17 to 26	. 55	. 30	0	. 48
27 to 52	. 30	0	0	0
3. *Temperature* (° *F.*)				
a. 0 to 39 (−18° to 4° C.)	0	0	0	----------
40 to 79 (5° to 26° C.)	. 12	. 12	0	----------
80 and up (27° C. and up)	. 23	. 23	0	----------
b. 30 to 49 (−1° to 9° C.)	----------	----------	0	0
50 to 69 (10° to 21° C.)	----------	----------	0	. 70
70 and up (22° C. and up)	----------	----------	0	1. 00
4. *Terrain*				
Open, level, scattered vegetation	. 30	. 30	0	. 30
Rugged, mountainous	0	[1] 0	[1] 0	[1] 0
5. *Precipitation*				
None	. 70	. 70	. 70	0
Moderate rain	0	[1] 0	[1] 0	[1] 0

[1] Estimated.
[2] Tentative figures not yet verified.

Figure 12. Effects components.

Note: paragraph 105 on page 82 states that the "safe entry times" after bio attacks are:

NU (Venezuelan equine encephalitis virus),
AB (bovine brucellosis), and
UL (tularemia): 2 hrs sun or 8 hrs cloudy
OU (Q fever): 2 hrs sun or 18 hrs cloudy

Cloudy conditions also apply to nighttime

626007 O—62——3

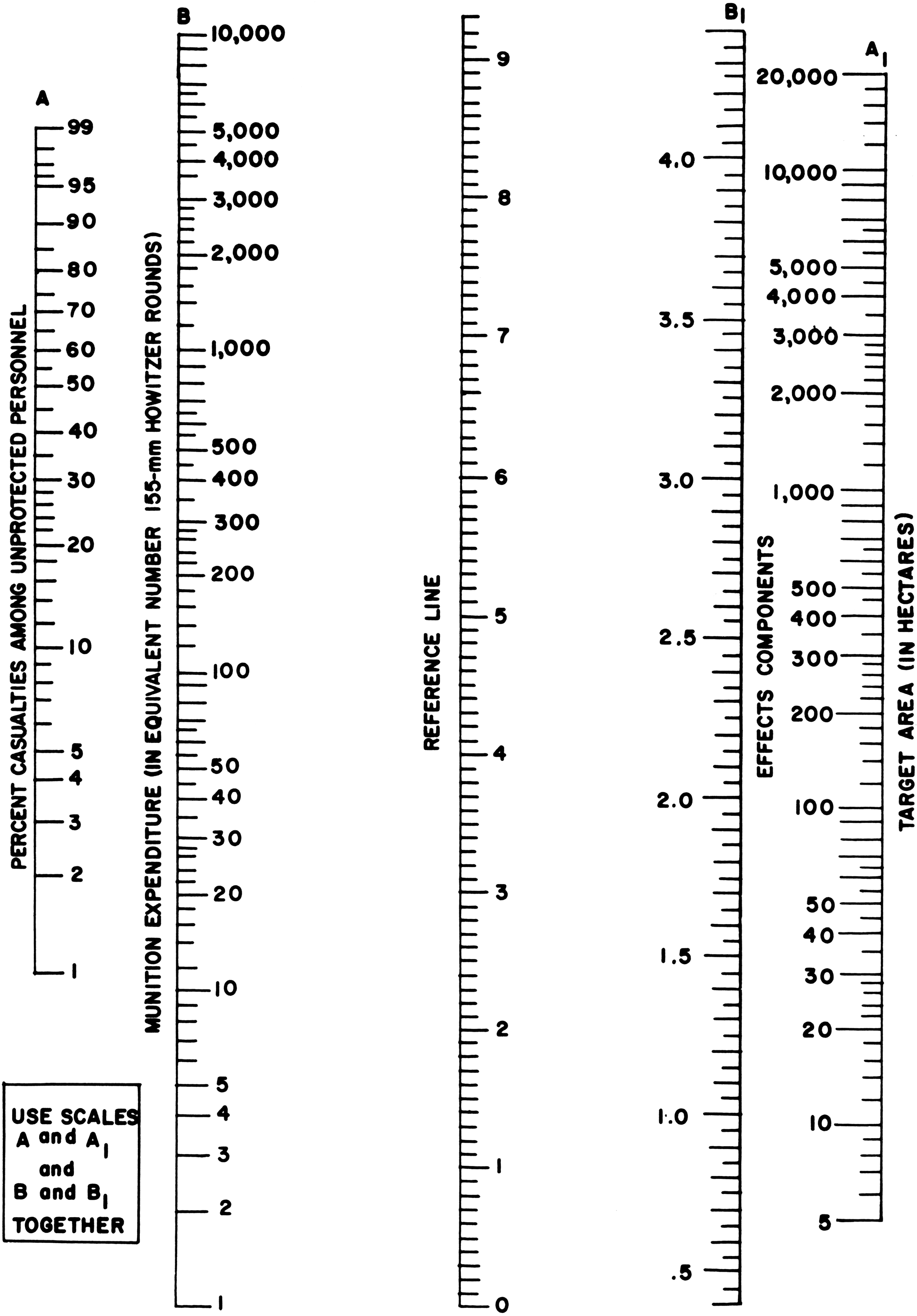


Figure 13. Target area, casualty level, munitions requirement nomogram.

DOWNWIND DISTANCE NOMOGRAM I

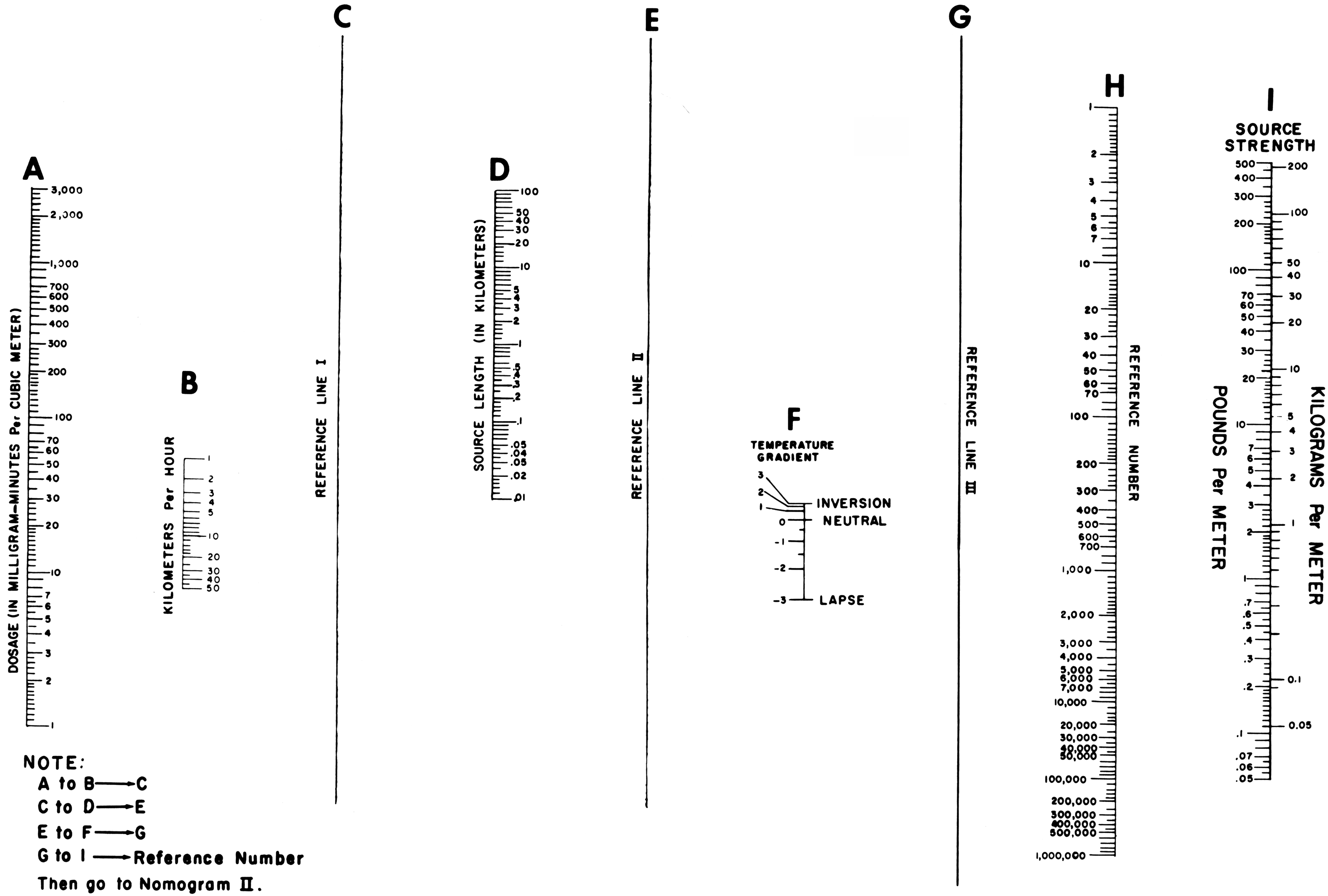


Figure 14. Downwind distance nomogram I.

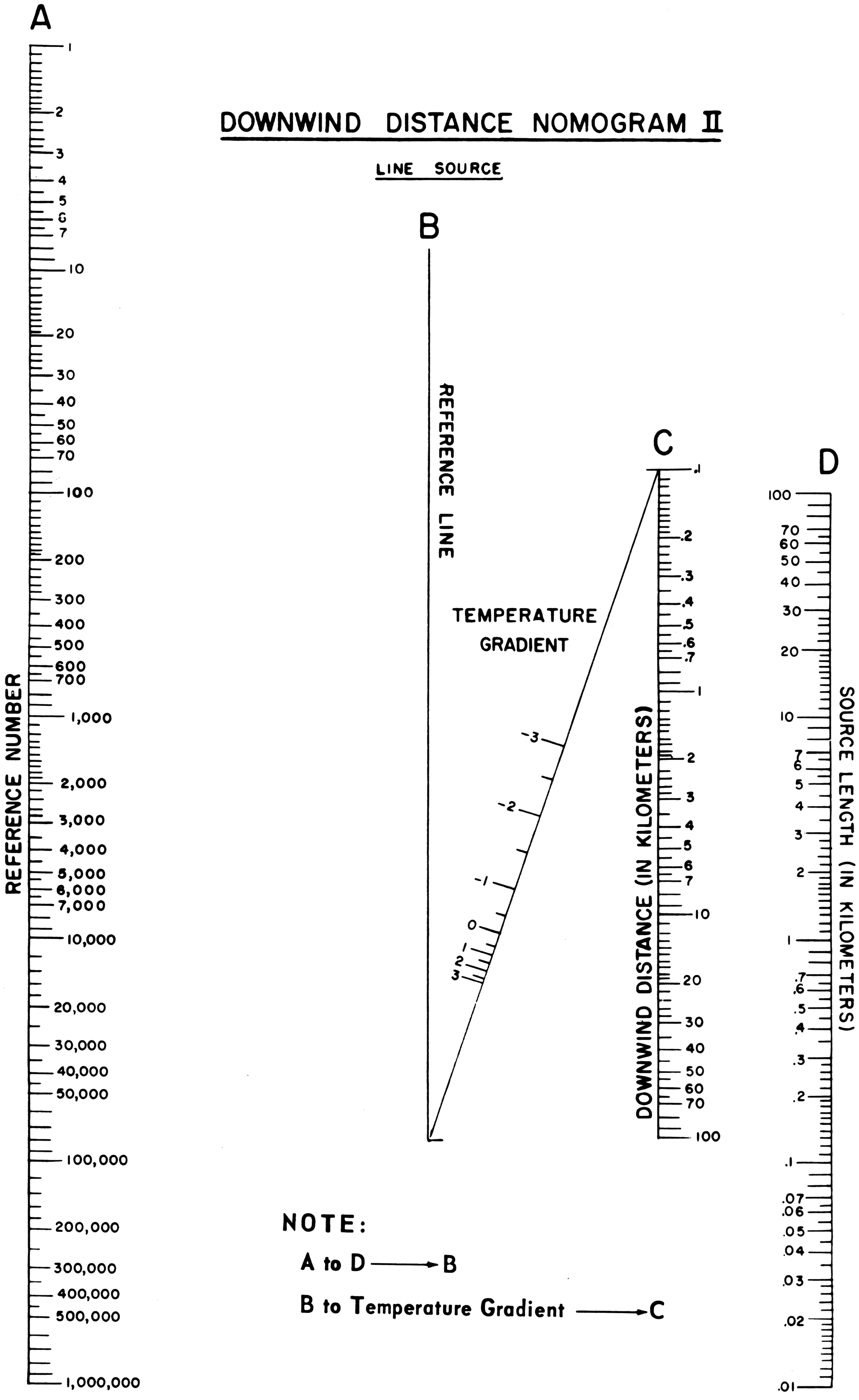


Figure 15. Downwind distance nomogram II.

REFERENCE BOOK

CHEMICAL AND BIOLOGICAL WEAPON EMPLOYMENT

U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
Fort Leavenworth, Kansas

1 May 1968

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CHAPTER 2
TOXIC CHEMICAL AGENTS

1. Characteristics and Effects

a. General. The following antipersonnel chemical agents are used for College instruction in chemical weapon employment: nerve agents GB and VX; blister agent HD (mustard); and incapacitating agent BZ. Actual or assumed characteristics of these agents are described in the following paragraphs for instructional purposes only and are summarized in figure 1.

b. Nerve Agent GB. GB is a quick acting, nonpersistent lethal agent that produces casualties primarily by inhalation.

(1) Inhalation effects. Inhaled GB vapor can produce casualties within minutes. As an example, 50 percent of a group of unprotected troops engaged in mild activity, breathing at the rate of about 15 liters per minute, and exposed to 70 milligrams of GB per cubic meter of air for 1 minute will probably die if they do not receive medical treatment in time. This is the median lethal dosage (50) and is expressed as 70 mg-min/m^3. For troops engaged in activities that increase their breathing rate, the median lethal dosage can be as low as 20 mg-min/m^3. The median incapacitating dosage of GB vapor by inhalation is about 35 mg-min/m^3 for troops engaged in mild activity. Incapacitating effects consist of nausea, vomiting, diarrhea, and difficulty with vision, followed by muscular twitching, convulsions, and partial paralysis. Dosages of GB less than the median incapacitating dosage cause general lowering of efficiency, slower reactions, mental confusion, irritability, severe headache, lack of coordination, and dimness of vision due to pinpointing of the eye pupils.

(2) Percutaneous effects. Percutaneous effects refer to those effects produced by the absorption of the agent through the skin. GB vapor absorbed through the skin can produce incapacitating effects. Sufficient GB liquid absorbed through the skin can produce incapacitation or death. The effectiveness of the liquid or vapor depends on the amount absorbed by the body. Absorption varies with the original amount of agent contamination, the skin area exposed and the exposure time, the amount and kind of clothing worn, and the rapidity in removing the contamination and/or contaminated clothing and in decontaminating affected areas of the skin.

(3) Major considerations in the employment of nerve agent GB. The employment of GB is based primarily on achieving casualties by inhalation of the nonpersistent vapor (or aerosol) of the agent. Major considerations in the employment of this agent are:

(a) Time to incapacitate. The onset of incapacitation resulting from inhalation of casualty-producing doses is rapid, the average time being approximately 3 minutes. To allow for the time required for the agent cloud to reach the individual, 10 minutes is used as the mean time to achieve incapacitation. Nonlethal casualties from GB will be incapacitated for 1 to 5 days.

(b) Persistency. Persistency is defined as the length of time an agent remains effective in the target area after dissemination. Nerve agent GB is considered nonpersistent. GB clouds capable of producing significant casualties will dissipate within minutes after dissemination. Some liquid GB will remain in chemical shell or bomb craters for periods of time varying from hours to days, depending on the weather conditions and type of munition. Because of this continuing but not readily discernible threat, GB can also be highly effective in harassing roles by causing exposure to low concentrations of the vapor. Rounds fired sporadically may compel the enemy to wear protective masks and clothing for prolonged periods, thereby impairing his effectiveness as a result of fatigue, heat stress, discomfort, and decrease in perception.

(c) Level of protection. The weapon system requirements for positive neutralization of masked personnel by GB are too great to be supported except for important point or small area targets. A major factor affecting casualties resulting from GB attacks of personnel equipped with masks but unmasked at the time of attack is the time required for enemy troops to mask after first detecting a chemical attack. Therefore, surprise dosage attack is used to establish a dosage sufficient to produce the desired casualties before troops can mask. Casualty levels for surprise dosage attack that are tabulated in the weapon system effects tables (app A) are based on an assumed enemy masking time of 30 seconds. (Refer to FM 3-10 series manuals for operational data for masking times less than 30 seconds.) A total dosage attack is used to build up the dosage over an extended period of time and is normally employed against troops who have no protective masks available. Dosages built up before troops can mask inside foxholes, bunkers, tanks, buildings, and similar structures will generally be less than dosages attained during the same period of time in the open, thereby reducing the effects on occupants from surprise dosage attacks. Total dosage effects are essentially the same inside or outside.

c. Nerve Agent VX. VX is a slow-acting, lethal, persistent agent that produces casualties primarily by absorption of droplets through the skin.

(1) Effects. VX acts on the nerve systems of man; interferes with breathing; and causes convulsions, paralysis, and death.

(2) Major considerations in the employment of nerve agent VX.

(a) General. Agent VX disseminated in droplet (liquid) form provides maximum duration of effectiveness as a lethal casualty threat. VX will remain effective in the target area for several days to a week depending on weather conditions. Because of its low volatility, there is no significant vapor hazard downwind of a contaminated area. Except when disseminated by aircraft spray tanks, meteorological conditions have little effect on the employment of VX, although strong winds may influence the distribution of the agent and heavy rainfall may wash it away or dissipate it.

(b) Employment to cause casualties. Agent VX is appropriate for direct attack of area targets containing masked personnel in the open or in foxholes without overhead protection, for causing severe harassment by the continuing casualty threat of agent droplets on the ground or on equipment, and for creating obstacles to traversing or occupying areas. Casualties produced by agent VX are delayed, occurring at times greater than 1 hour after exposure. Although this agent can be used relatively close to friendly forces, it should not be used on positions that are likely to be occupied by friendly forces within a few days. Because of this continuing hazard, areas in which agent VX has been used should be recorded in a manner similar to minefields or fallout areas so that necessary precautions can be taken.

d. Blister Agent HD. HD, sometimes referred to as mustard, is a persistent slow-acting agent that produces casualties through both its vapor and liquid effects.

(1) Vapor effects.

(a) The initial disabling effect of HD vapor on unmasked troops will be injuries to the eyes. Temporary blindness can be caused by vapor dosages that are insufficient to produce respiratory damage or skin burns. However, skin burns account for most injuries to masked troops. The vapor dosages and the time required to produce casualties (4 to 24 hours) vary with the atmospheric conditions of temperature and humidity and with the amount of moisture on the skin. Depending on their severity, skin burns can limit or entirely prevent movement of the limbs or of the entire body.

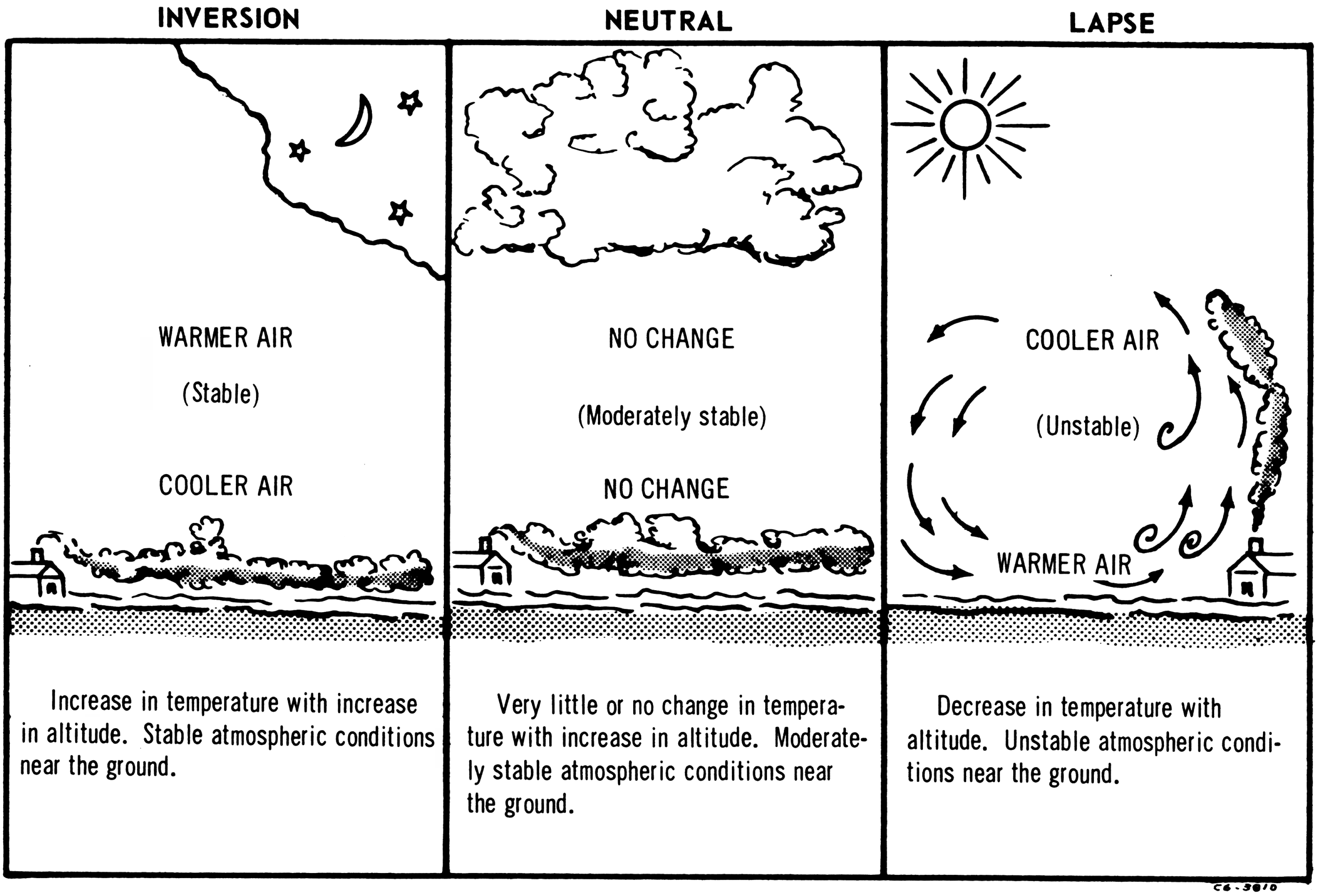

Figure 2. Temperature gradients.

Surprise dosage GB attacks are influenced only slightly by the temperature gradient except when made with the spray tank. Downwind vapor hazards to both enemy and friendly forces will be most significant during inversion and neutral conditions. Employment of VX is not affected by the temperature gradient.

Temperature gradients	Time
1. Inversion	From sunset to sunrise.
2. Neutral	2 hours before sunset to sunset, sunrise to 2 hours after sunrise, or any time windspeed is 15 kmph or greater.
3. Lapse	2 hours after sunrise to 2 hours before sunset.

Figure 3. Estimated times that temperature gradients will prevail. (Use when meteorological data are not available.)

(3) When actual or predicted meteorological conditions are not available for a target analysis, 70° F is used for temperature, 9 kmph is used as windspeed, and the temperature gradient is approximated from figure 3.

d. Windspeed and Direction.

(1) Air moving over the earth's surface sets up eddies, or mechanical turbulences, that act to dissipate a chemical cloud. A condition of calm will limit the merging of the individual gas clouds. Both of these conditions may reduce the effectiveness of a chemical agent attack. High winds increase the rate of evaporation of HD and dissipate chemical clouds more rapidly than low winds. Moderate winds are desirable for chemical employment. Large-area nonpersistent chemical attacks are most effective in winds not exceeding 28 kmph. Small-area nonpersistent chemical attacks with rockets or shell are most effective in winds not exceeding 9 kmph. However, if the concentration of chemical agent can be established quickly, the effects of high windspeed can be partially offset.

CHAPTER 4
EMPLOYMENT OF BIOLOGICAL AGENTS

1. General

a. Antipersonnel biological agents are micro-organisms that produce disease in man. These agents can be used to incapacitate or kill enemy troops through disease. They may cause large numbers of casualties over vast areas and could require the enemy to use many personnel and great quantities of supplies and equipment to treat and handle the casualties. Many square kilometers can be effectively covered from a single aircraft or missile. The search capability of biological agent clouds and the relatively small dose required to cause infection among troops give biological munitions the capability of covering large areas where targets are not precisely located.

b. A biological attack can occur without warning since biological agents can be disseminated by relatively unobtrusive weapon systems functioning at a considerable distance from the target area and relying upon air movement to carry the agent to the target.

c. Biological agents do not produce effects immediately. An incubation period is required from the time the agent enters the body until it produces disease. Some agents produce the desired casualty levels within a few days, whereas others may require more time to produce useful casualty levels. A variety of effects may be produced, varying from incapacitation with few deaths to a high percentage of deaths, depending on the type of agent.

2. Methods of Dissemination

a. The basic method of disseminating antipersonnel biological agents is the generation of aerosols by explosive bomblets and spray devices. Because exposure to sunlight increases the rate at which most biological agent aerosols die and thereby reduces their area coverage, night is the preferable time for most biological attacks. However, if troop safety is a problem, an attack may be made near sunrise to reduce the distance downwind that a hazard to friendly forces will extend. Conversely, to extend the downwind cloud travel and the area coverage from spray attack, a biological agent may be employed soon after sundown.

b. Missile-delivered Biological Munitions. Missile-delivered biological munitions are used for attack of large-area targets. A typical biological missile system consists of the following components:

(1) A missile vehicle and its launching equipment.

(2) A warhead that can be opened at a predetermined height to release biological bomblets over the target area. The warhead is shipped separately for assembly to a missile at the launching site.

(3) A warhead shipping container equipped with a heating-cooling element and a temperature control unit.

(4) Biological bomblets consisting of an agent container and a central burster that functions on impact. The bomblets have vanes that cause them to rotate in flight, thereby achieving lateral dispersion during their free fall and resulting in random distribution as a circular pattern.

c. Aircraft Spray Tank. Biological agents released from an aircraft spray tank cover a large area downwind of the line of release. A typical spray tank consists of the following components:

(1) An agent reservoir section that is shipped separately in an insulated shipping and storage container equipped with a heating-cooling element and a temperature control unit.

(2) A discharge nozzle assembly that can be mechanically adjusted to vary the agent flow rate.

Table 1. Chemical Weapons Data

1	2	3	4	5	6	7	8	9	10	11	12	13
Delivery system	Range (meters) Min	Range (meters) Max	Agent	Munition	No of weapons per delivery unit	Weapon rate of fire	RT max (meters)[1 2] Fire unit	Total dosage Casualty threat 10%	Total dosage Casualty threat 30%	Surprise dosage Casualty threat 10%	Surprise dosage Casualty threat 30%	Reference (table)
4.2-in mortar	180	4,500	HD	Cartridge, M2A1	4/Plat	50 rd/3 min 105 rd/15 min						18 19
105-mm howitzer		11,100	GB	Cartridge, M360	6/btry	5 rd/30 sec	1 btry[3]	200	100	100	50	2
						30 rd/3 min	1 bn[3]	300	300	200	100	3
			HD	Cartridge, M60		66 rd/15 min						18 19
155-mm howitzer		14,600	GB	Projectile, M121	6/btry	2 rd/30 sec	1 btry[3]	300	200	100	0	4
						12 rd/3 min	1 bn[3]	500	400	300	100	5
			HD	Projectile, M110		24 rd/15 min						18 19
			VX[4]	Projectile, M121			1 btry[3]	400	200	NA	NA	13
							1 bn[3]	500	400			
8-in howitzer		16,800	GB	Projectile, M426	4/btry	1 rd/30 sec	1 btry[3]	300	200	200	0	6
						4 rd/3 min	1 bn[3]	500	400	300	100	7
			VX[4]			10 rd/15 min	1 btry[3]	400	200	NA	NA	14
							1 bn[3]	500	400			
115-mm multiple rocket launcher, M91	2,740	10,600	GB[4]	Rocket, M55 (THE BOLT)		45 rkt/lchr/15 sec	1 lchr	1,000	750	500	200	8
							3 lchr	1,000	1,000	750	400	
							6 lchr	1,000	1,000	1,000	750	
							9 lchr	1,000	1,000	1,000	1,000	
			VX[4]				1 lchr	300	0	NA	NA	15
							3 lchr	750	300			
							6 lchr	1,000	400			
							9 lchr	1,000	750			
762-mm rocket, Honest John	8,500	38,000	GB[4]	Warhead, M190 (M139 bomblets)	2/btry	2 rkt/lchr/hr	1 lchr	600	600	600	400	9
							2 lchr	600	600	600	400	
Sergeant missile	46,000	139,000	GB[4]	Warhead, M212 (M139 bomblets)	2/bn	2 msl/lchr/hr	1 msl	600	400	600	200	10
							2 msl	600	600	600	400	
Aircraft	Dependent on type aircraft		GB[4]	Bomb, MC-1, 750-lb		Dependent on type aircraft	1 bomb	50				11
							6 bombs	300	200	300	50	
							12 bombs	500	300	400	200	
							24 bombs	500	300	500	300	
			GB[4]	Spray tank, 100-gal			1 spray tank 2 spray tanks	RT max=750 meters (one-half effective spray release line length)				12
			VX[4]				1 spray tank	RT max=500 meters (one-half effective spray release line length)				16
			BZ[4]	Bomb, 150-lb Bomb, 700-lb								17

[1]RT max is largest target radius for which indicated casualty threat is tabulated for appropriate fire unit. Division of target into subtargets NOT considered.

[2]All windspeeds, temperature gradients, and protection categories considered.

[3]RT max computed for maximum number of volleys for which data are tabulated.

[4]Weapon system capabilities derived from tables composed of hypothetical data for INSTRUCTIONAL PURPOSES ONLY at the U. S. Army Command and General Staff College. For actual data, refer to FM 3-10.

Table 2. Estimated Fractional Casualty Threat From 105-mm Howitzer, GB Projectile, Battery Fire[1,2]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Target radius–radius of effect (meters)	Range to target (km)	No of volleys	Windspeed[3]											
			4 kmph				9 kmph				28 kmph			
			Surprise[4]	Total dose[5]			Surprise[4]	Total dose[5]			Surprise[4]	Total dose[5]		
				I	N	L		I	N	L		I	N	L
50	<7.5	1	.10	.25	.20	.15	.10	.15	.10	.10				
		2	.20	.45	.40	.30	.15	.30	.25	.20		.10	.05	.05
		3	.30	.60	.60	.35	.30	.50	.45	.30	.10	.20	.15	.10
		4	.30	.75	.70	.45	.30	.55	.45	.35	.10	.25	.20	.10
		5	.35	.90	.85	.55	.35	.60	.50	.40	.15	.30	.25	.15
	>7.5	1	.05	.15	.15	.10	.05	.10	.05	.05				
		2	.15	.30	.25	.15	.10	.20	.15	.10		.05	.05	
		3	.15	.30	.30	.25	.10	.20	.20	.15		.10	.05	.05
		4	.20	.40	.35	.25	.15	.30	.30	.15	.05	.15	.15	.05
		5	.25	.45	.45	.30	.25	.40	.35	.25	.10	.20	.20	.10
100	<7.5	1	.05	.15	.15	.10	.05	.10	.05	.05				
		2	.10	.30	.30	.15	.10	.20	.15	.10				
		3	.15	.40	.35	.20	.15	.25	.25	.15	.05	.10	.05	
		4	.15	.40	.35	.30	.15	.30	.30	.15	.05	.10	.10	.05
		5	.20	.45	.40	.35	.20	.35	.35	.20	.10	.15	.15	.10
	$\geq$7.5	1	.05	.10	.10	.05		.05	.05					
		2	.10	.20	.20	.10	.05	.15	.10	.05				
		3	.10	.25	.25	.15	.10	.15	.15	.10		.05	.05	
		4	.10	.30	.25	.20	.10	.25	.20	.15		.10	.05	
		5	.15	.35	.30	.25	.15	.30	.25	.15	.05	.15	.10	.05
200	Any	1		.05	.05									
		2		.10	.10	.05		.05	.05					
		3	.05	.15	.15	.05		.10	.05					
		4	.05	.15	.15	.10		.10	.10					
		5	.05	.20	.20	.10	.05	.15	.10	.05				

[1]Blank spaces indicate fractional casualties are below 0.05.

[2]If the target is predominately wooded, use a windspeed of 4 kmph and neutral temperature gradient for total dose attack; use a windspeed of 4 kmph for surprise attack.

[3]For windspeeds other than those shown, use data given for the nearest windspeed.

[4]Multiply the figures given in the table by the appropriate factor to obtain the fractional casualties from surprise dose attack:

Troops in open foxholes:	0.7
Troops in covered foxholes or bunkers:	0.6

[5]I=inversion, N=neutral, L=lapse.

Table 17. BZ Munitions Requirements

1	2	3	4	5	6
Munition	Casualty level[2]	Area coverage[1] (square kilometers)			
		Windspeed[3]			
		8 kmph		16 kmph	
		Temperature gradient		Temperature gradient	
		Inversion	Neutral	Inversion	Neutral
150-lb bomb	.40	.05	.02	.03	.01
	.75	.03	.01	.02	.009
700-lb bomb	.40	.20	.07	.09	.04
	.75	.10	.04	.05	.03

[1]Area coverages are for one bomb.

[2]Casualty levels are for personnel without masks available. For personnel with masks available, multiply casualty levels by 0.7.

[3]For windspeeds other than those shown, use data given for the nearest windspeed.

NOTE: The above table is composed of hypothetical munitions and data for INSTRUCTIONAL PURPOSES ONLY at the U. S. Army Command and General Staff College. For actual data, refer to FM 3-10.

Table 18. HD Ammunition Expenditure for Vapor Effect (50 Percent Coverage of Target Area)[1 2]

Rounds required per hectare — 4.2-inch mortar (cartridge M2A1)

Desired effect[3]	Exposure time (hours) — Temperature (°F) 55°	70°	85°	100°	Windspeed (kmph) 6 — Temperature gradient[4] I	N	L	9 I	N	L	15 I	N	L	26 I	N	L
Cause eye irritation to troops without masks.	1	½	¼	⅛	10	14	16	11	21	22	15	22	26	20	24	29
	2	1	½	¼	6	8	9	8	12	14	12	13	16	17	21	24
	4	2	1	½	6	6	8	8	9	10	9	10	13	13	16	20
	8	4	2	1	4	6	6	6	8	9	8	9	11	12	13	15
	16	8	4	2	4	5	5	5	8	9	8	8	10	10	11	13
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	35	46	52	39	53	63	46	63	80	59	77	108
	2	1	½	¼	20	29	33	24	35	40	30	45	56	41	59	69
	4	2	1	½	15	21	24	17	27	33	24	35	42	30	47	65
	8	4	2	1	11	17	18	13	21	26	17	28	38	27	45	63
	16	8	4	2	9	14	16	11	18	22	16	24	33	24	42	58
Disable masked troops (dry weather).	1	½	¼	⅛	64	83	95	72	95	114	86	113	144	108	144	198
	2	1	½	¼	36	52	58	44	62	72	57	81	101	71	120	125
	4	2	1	½	26	35	41	30	46	56	45	62	76	57	86	119
	8	4	2	1	18	27	30	23	35	44	32	50	68	50	81	114
	16	8	4	2	13	21	26	18	30	40	29	46	60	42	72	108

Rounds required per hectare — 105-mm howitzer (cartridge M60)

Desired effect[3]	Exposure time (hours) — Temperature (°F) 55°	70°	85°	100°	Windspeed (kmph) 6 — Temperature gradient[4] I	N	L	9 I	N	L	15 I	N	L	26 I	N	L
Cause eye irritation to troops without masks.	1	½	¼	⅛	22	24	27	24	34	39	39	44	46	32	53	65
	2	1	½	¼	18	22	23	20	22	27	29	32	34	26	39	51
	4	2	1	½	16	17	20	17	18	20	20	22	24	22	29	39
	8	4	2	1	12	15	17	13	12	17	15	20	22	18	27	36
	16	8	4	2	10	12	13	10	11	15	12	17	20	15	24	34
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	70	83	108	77	95	121	95	123	166	108	157	243
	2	1	½	¼	42	54	63	47	63	84	66	89	102	82	108	192
	4	2	1	½	27	36	45	32	47	62	48	64	84	64	88	162
	8	4	2	1	18	29	34	24	38	47	33	53	76	54	83	138
	16	8	4	2	15	23	27	18	32	42	30	51	66	48	72	120
Disable masked troops (dry weather).	1	½	¼	⅛	128	154	174	144	174	212	189	...	...	202	...	...
	2	1	½	¼	75	98	128	89	113	147	111	156	180	148	198	288
	4	2	1	½	50	64	81	59	86	111	88	118	153	117	165	256
	8	4	2	1	33	50	58	45	65	84	62	95	138	101	154	240
	16	8	4	2	26	39	45	34	56	72	54	84	120	84	132	193

Rounds required per hectare — 155-mm howitzer and gun (projectiles M110 and M104)

Desired effect[3]	Exposure time (hours) — Temperature (°F) 55°	70°	85°	100°	Windspeed (kmph) 6 — Temperature gradient[4] I	N	L	9 I	N	L	15 I	N	L	26 I	N	L
Cause eye irritation to troops without masks.	1	½	¼	⅛	8	10	10	9	11	12	10	12	13	11	14	16
	2	1	½	¼	6	8	9	8	10	11	9	11	12	10	12	14
	4	2	1	½	4	5	6	6	8	9	8	9	10	9	10	12
	8	4	2	1	4	5	5	5	6	8	6	8	9	8	9	11
	16	8	4	2	4	4	4	4	5	6	5	6	8	5	8	10
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	20	28	30	23	32	36	26	39	44	32	46	58
	2	1	½	¼	12	17	20	15	22	24	18	27	34	24	36	46
	4	2	1	½	10	13	16	11	18	20	15	20	27	18	29	33
	8	4	2	1	6	10	12	9	13	16	12	17	24	16	23	33
	16	8	4	2	5	9	11	8	11	15	11	15	22	15	20	29
Disable masked troops (dry weather).	1	½	¼	⅛	36	48	53	41	56	63	46	66	78	59	83	105
	2	1	½	¼	21	28	33	26	36	41	38	54	63	42	65	84
	4	2	1	½	15	21	26	18	28	33	26	36	45	33	50	66
	8	4	2	1	11	16	18	13	21	26	22	33	40	28	42	56
	16	8	4	2	9	12	15	11	18	21	18	30	36	24	38	46

[1]For open terrain. For heavily wooded terrain or jungle, multiply the figure obtained by 0.5 to obtain the appropriate expenditure.

[2]Blank spaces indicate excessive expenditures.

[3]An average of 50 percent casualties is expected among all troops who remain in the target area for the times specified.

[4]I = inversion, N = neutral, L = lapse.

[redacted]

S/C

DEPARTMENT OF THE ARMY FIELD MANUAL FM 3–10B

NAVAL WARFARE INFORMATION PUBLICATION NWIP 36–4

DEPARTMENT OF THE AIR FORCE MANUAL AFM 355–9

MARINE CORPS MANUAL FMFM 11–3B

EMPLOYMENT OF CHEMICAL AGENTS (U)

This copy is a reprint which includes current pages from Changes 1.

[redacted]

[redacted]

DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE

NOVEMBER 1966

[redacted]

6. ~~(C)~~ (U) Incapacitating Agent BZ

This agent is disseminated as an aerosol to produce physical and mental effects when inhaled. The effects are temporary, and recovery is normally complete. There may be permanent ill effects in a few instances among the very young, the aged, and the infirm, or when massive dosages are received.

a. Tactical Employment. BZ is employed against carefully selected targets to incapacitate enemy troops when the use of lethal or destructive munitions is undesirable. This agent may be particularly useful in situations where adequate protective equipment is normally not available to enemy troops or where the status of training or mask discipline is poor, such as in counterinsurgency operations.

b. Limitations. BZ has the following limitations:

(1) The white agent cloud produced by pyrotechnic mixtures acts as a visible alarm.

(2) BZ may be defeated by improvised respiratory protection such as a folded cloth over mouth and nose.

(3) The effects are not immediate but require an average onset time of about 3 to 6 hours.

(4) There is no known antidote to treat affected friendly personnel.

c. Median Incapacitating Dosage (ICt_{50}). This is about 110 mg-min/m^3 for man engaged in mild activity (breathing rate of 15 liters/min).

d. Physiological and Psychological Symptoms. The symptoms listed below will become more intense as the dosage received increases. They also vary according to the inherent characteristics of each individual exposed to the agent. Because of the many variables involved, estimation of the percentage and type of casualties produced from a BZ attack is difficult. Approximations for the occurrence of ultimate casualties among unmasked personnel are 5 percent in 2 hours, 50 percent in 4½ hours, and 95 percent in 9½ hours.

(1) Symptoms likely to appear in 30 minutes to 3 hours: dizziness, extreme drowsiness, dryness of the mouth, and increased heartbeat.

(2) Symptoms likely to appear in 3 to 5 hours: restlessness, involuntary muscular movement, near vision impairment, and physical incapacitation.

(3) Symptoms likely to appear in 6 to 10 hours: hallucinations, lack of muscular coordination, disorientation, and difficulty in memory recall.

e. Duration of Incapacitation. The duration of incapacitation varies with the dosage received—from 24 hours to 5 days.

f. Duration of Effectiveness. Under average meteorological conditions in the open, the aerosol is normally effective for only a few minutes after dissemination, since the fine BZ particles travel

[redacted]

27. (U) CBU-5B/M43 750-Pound BZ Cluster Bomb

Both the U.S. Air Force CBU-5B and the U.S. Army M43 750-pound cluster bombs contain 57 M138 BZ-filled bomblets. The U.S. Army M43 cluster is designed for delivery by aircraft at low speeds. When modified and equipped with a suitable fairing for streamlining purposes, an internal arming wire system, and a strengthened tail fin, it is then designated the CBU-5B and can be delivered by high-performance aircraft.

a. Operational Concepts. The BZ cluster bomb is used on carefully selected targets against enemy personnel when the use of lethal chemical or destructive weapon systems is militarily or politically undesirable. See paragraph 6 for additional data.

b. Characteristics. The cluster contains about 85 pounds of agent BZ and employs two tail mechanical time fuzes. To function properly, the cluster must be released above 6,200 feet so as to allow the cluster to open at approximately 4,500 feet. The M138 bomblet contains four canisters, each with three-fourth pound of agent-pyrotechnic mixture (50/50 ratio), and an "all-ways" impact fuze. The bomblet is *not* self-dispersing.

c. Capabilities. The cluster delivers M138 bomblets over an elliptical impact area having a cross section of approximately 100 by 200 meters when released at heights above 6,200 feet. One cluster can cover about 12,000 square meters (1.2 hectares) with an incapacitating total dosage of BZ (110 mg–min/m^3) under neutral temperature gradient and in a wind speed between 2 and 10 knots; under lapse temperature gradient conditions, the area coverage will be smaller. Under optimum delivery conditions, the area coverage for one cluster is expected to range from 15,000 to 20,000 square meters. Field tests indicate that wind speed has only minor effects upon area coverage.

d. Operational Considerations. Refer to the appropriate technical order/flight manual to determine aircraft loads (see para 16*d*).

[redacted]

Field Manual
No 3-6

Air Force Manual
No 105-7

Fleet Marine Force Manual
No. 7-11-H

HEADQUARTERS
DEPARTMENT OF THE ARMY
DEPARTMENT OF THE AIR FORCE
UNITED STATES MARINE CORPS
Washington, DC, 3 November 1986

FIELD BEHAVIOR OF NBC AGENTS (INCLUDING SMOKE AND INCENDIARIES)

Table of Contents

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DISPERSION CATEGORY	ATMOSPHERIC DESCRIPTION	TRADITIONAL ATMOSPHERIC CONDITIONS
1	Very Unstable	Lapse
2	Unstable	Lapse
3	Slightly Unstable	Neutral
4	Neutral	Neutral
5	Slightly Stable	Neutral
6	Stable	Inversion
7	Extremely Stable	Inversion

Figure 1-1. Atmospheric stability categories and conditions.

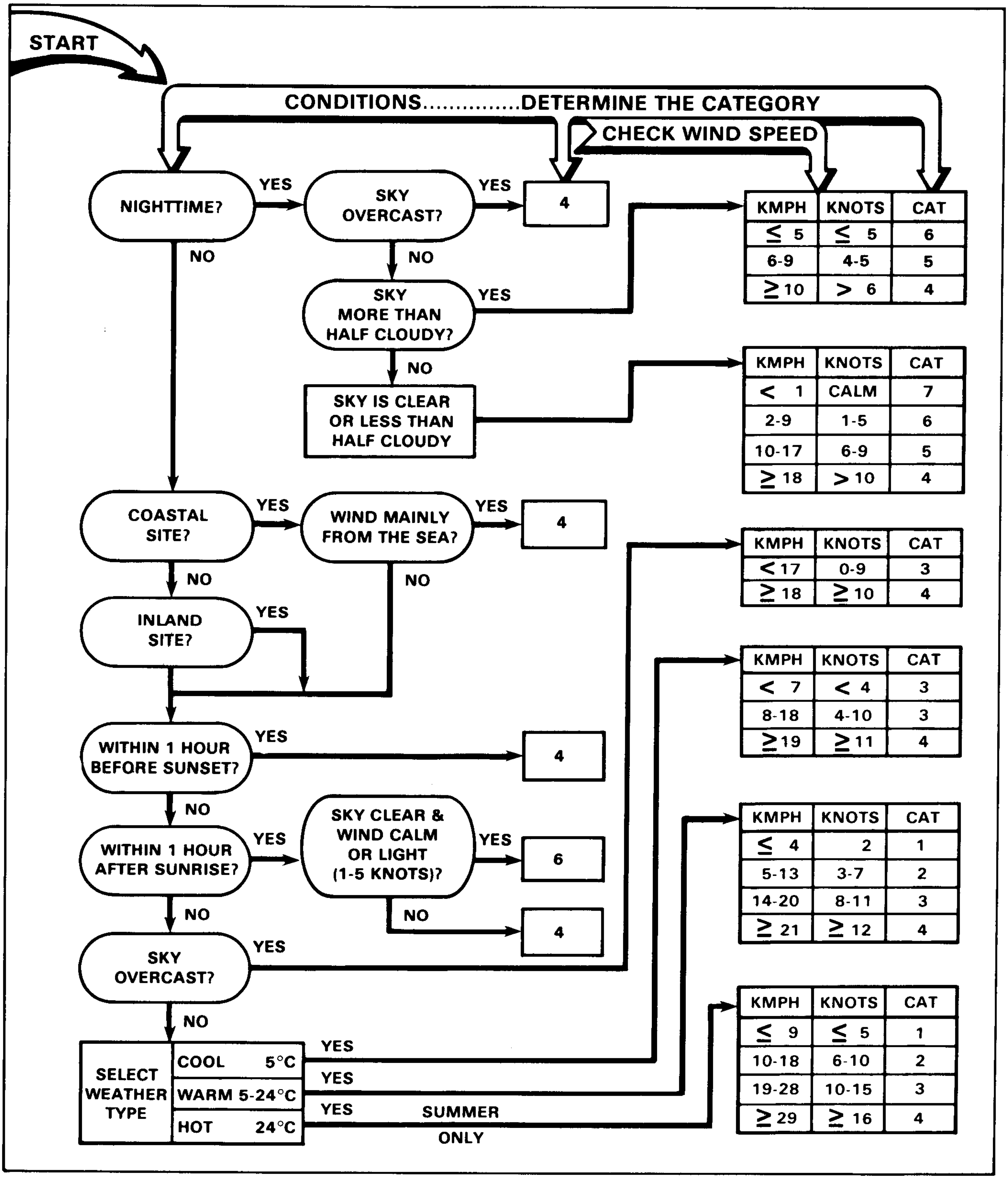


Figure 1-2. Stability decision tree.

Page 1-14 states that the mixed air layer height is 50-100 m on a clear, calm night, 400 m just before sunrise, and 2 km on a hot summer day

Table 1-3. Center line dosages at different distances downwind for different dispersion categories and wind speeds for a unit source. 100 kilograms of GB

Stability Category	Wind Speed	DOWNWIND DISTANCE IN KM .5	1	2	4	6	10	20	30
		DOSAGES (mg-min/M³)							
1	1	57.82	10.960	2.4820	1.2070	.8048	.48290	.24140	.16100
1	3	19.15	3.628	.8224	.3998	.2665	.15990	.07995	.05330
1	5	11.47	2.174	.4928	.2396	.1597	.09582	.04791	.03194
2	3	65.93	16.480	4.121	1.0300	.4671	.22840	.11360	.07575
2	6	32.86	8.215	2.054	.5135	.2328	.11380	.05663	.03775
2	10	19.75	4.938	1.235	.3087	.1400	.06843	.03404	.02269
3	3	172.60	46.26	12.400	3.321	1.5370	.5825	.18010	.11510
3	7	73.86	19.79	5.302	1.421	.6576	.2492	.07703	.04925
3	12	43.09	11.55	3.094	.829	.3837	.1454	.04494	.02874
4	3	572.4	170.20	50.590	15.040	7.398	3.0260	.8997	.44450
4	8	213.9	63.61	18.910	5.622	2.765	1.1310	.3363	.16620
4	16	107.1	31.84	9.467	2.814	1.384	.5662	.1683	.08318
5	2	1,837.0	606.0	199.90	65.94	34.470	15.220	5.021	2.6250
5	5	736.2	242.9	80.12	26.43	13.810	6.101	2.012	1.0520
5	9	408.7	134.8	44.47	14.67	7.668	3.387	1.117	.5839
6	1	10,080.0	3,691.0	1,351.0	494.50	274.70	131.00	47.930	26.630
6	3	3,339.0	1,222.0	447.4	163.80	90.96	43.37	15.870	8.818
6	5	2,001.0	732.4	268.1	98.12	54.51	25.99	9.5120	5.284
7	HIGHER DOSAGES THAN ABOVE								

Table 1-4. Summary of favorable and unfavorable weather and terrain conditions for tactical employment of chemical agent vapor or aerosol. (The stability condition listed for the south slope is for the northern hemisphere; due to solar loading on the slope, the situation would be reversed for the southern hemisphere.)

FACTOR	UNFAVORABLE	MODERATELY FAVORABLE	FAVORABLE
Wind	Artillery employment if speed is more than 7 knots. Aerial bombs if speed is more than 10 knots.	Steady, 5 to 7 knots, or land breeze.	Steady, less than 5 knots, or sea breeze.
Dispersion Category	Unstable (lapse).	Neutral.	(Stable) inversion.
Temperature	Less than 4.4°C.	4.4° to 21.1°C.	More than 21.1°C.
Precipitation	Any.	Transitional.	None.
Cloud Cover	Broken, low clouds during daytime. Broken, middle clouds during daytime. Overcast or broken, high clouds during daytime. Scattered clouds of all types during daytime. Clouds of vertical development.	Thick, low overcast. Thick, middle overcast.	Broken, low clouds at night. Broken, middle clouds at night. Overcast or broken, high clouds at night. Scattered clouds of all types at night. Clear sky at night.
Terrain	Hilltops, mountain crests. South slopes* during daytime.	Gently rolling terrain. North slopes at night.	Even terrain or open water.
Vegetation*	Heavily wooded or jungle.	Medium dense.	Sparse or none.

*Cloud dissemination occurs above the canopy.

Chemical and biological contamination avoidance, FM 3-3 (1992)

10 grams/square meter

TABLE 1-2. Chemical Agent Persistency in Hours on CARC Painted Surfaces.

Temperature		GA/ GF[1]	GB[2,3]	GD[2,3]	HD[1]	VX[2,3]
C°	F°					
-30	-22	*	110.34	436.69	**	***
-20	-4	*	45.26	145.63	**	***
-10	14	*	20.09	54.11	**	***
0	32	*	9.44	22.07	**	***
10	50	1.42	4.70	9.78	12	1776
20	68	0.71	2.45	4.64	6.33	634
30	86	0.33	1.35	2.36	2.8	241
40	104	0.25	0.76	1.25	2	102
50	122	0.25	0.44	0.70	1	44
55	131	0.25	0.34	0.51	1	25

NOTE

1 For grassy terrain multiply the number in the chart by 0.4.
2 For grassy terrain multiply the number in the chart by 1.75.
3 For sandy terrain multiply the number in the chart by 4.5.
* Agent persistency time is less than 1 hour.
** Agent is in a frozen state and will not evaporate or decay.
*** Agent persistency time exceeds 2,000 hours.

REFERENCE BOOK
3—2*

U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
Fort Leavenworth, Kansas, *25 July 1983*

CHEMICAL WEAPONS EMPLOYMENT DATA

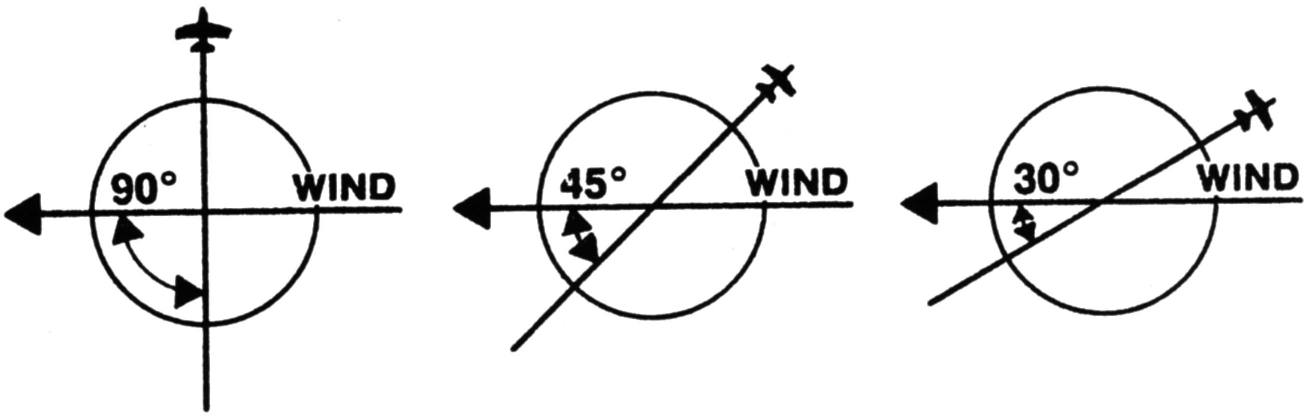
*This reference book replaces RB 3—2, 8 July 1981, for all resident and nonresident programs.

Section X
Spray Tank/VX

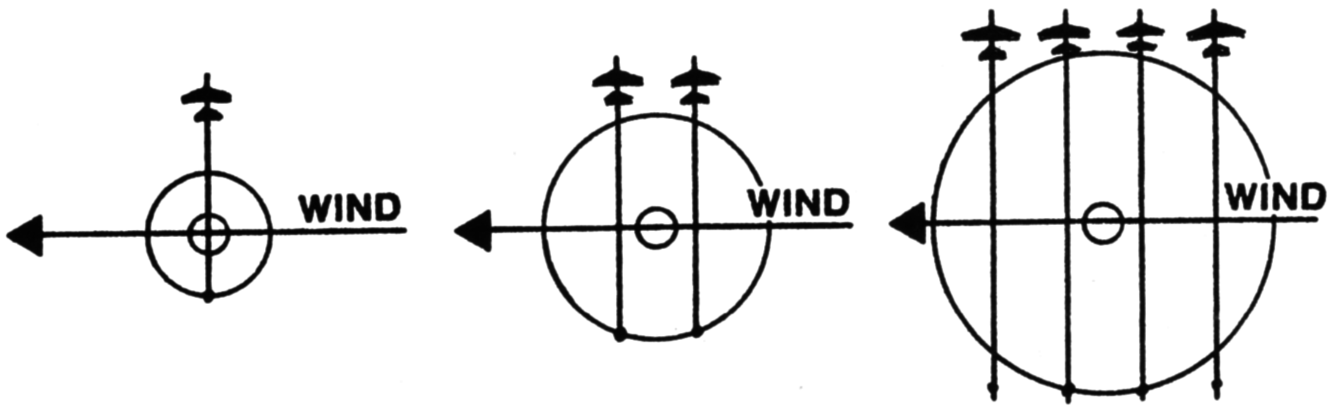
AIM POINT & FLIGHT PATH ADJUSTMENTS
VARIABLE DELIVERY TECHNIQUES

DELIVERY SYSTEM	**TANKS/AIRCRAFT**	**AIRCRAFT SPEED***
Refer to Air Force & Navy Publications	Minimum 1 Maximum 2	450 Knots Centered Delivery

$$\text{Altitude of Spray Release Line} = \frac{\text{Windspeed - Height Product (VWH)}}{\text{Windspeed in Knots}}$$



FLIGHT PATH IN RELATION TO WIND DIRECTION



500-M TARGET RADIUS   1,000-M TARGET RADIUS   1,500-M TARGET RADIUS

Flight path Initiation point is leading edge of target Target center

Used on all tables in this section.

Table I-79. Spray Tank/VX Aim Point & Flight Path Adjustments

Spray Tank/VX

Expected Fraction of Casualties

PROTECTION CATEGORY: A (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: 1/2 HOUR

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	VWH 500 NO. AIRCRAFT 1	500: 2	500: 4	VWH 750 NO. AIRCRAFT 1	750: 2	750: 4	VWH 1000 NO. AIRCRAFT 1	1000: 2	1000: 4	VWH 2000 NO. AIRCRAFT 1	2000: 2	2000: 4	VWH 3000 NO. AIRCRAFT 1	3000: 2	3000: 4
ONE TANK AT HALF FLOW	90°	500	.06	.15	.20	.17	.37	.60	.25	.46	.68	.25	.43	.60	.19	.35	.50
		1000	.01	.04	.10	.06	.15	.31	.09	.19	.45	.09	.20	.45	.09	.20	.45
		1500	–	.02	.07	–	.06	.14	–	.06	.19	–	.06	.22	–	.08	.23
	45°	500	.04	.11	.23	.13	.29	.61	.20	.41	.69	.22	.41	.64	.21	.37	.57
		1000	.01	.04	.11	.04	.10	.23	.07	.16	.36	.08	.19	.42	.08	.19	.42
		1500	–	–	.07	–	.06	.12	–	.08	.18	–	.08	.20	–	.08	.22
	30°	500	.02	.07	.16	.10	.23	.48	.15	.32	.64	.17	.36	.62	.18	.35	.57
		1000	–	.03	.08	.03	.09	.20	.06	.13	.29	.07	.15	.34	.07	.16	.36
		1500	–	–	.04	–	.04	.09	–	.06	.14	–	.08	.18	–	.08	.20
TWO TANKS AT HALF FLOW	90°	500	.08	.17	.30	.22	.46	.69	.34	.55	.69	.31	.50	.65	.25	.43	.60
		1000	.01	.05	.11	.10	.19	.41	.13	.29	.61	.15	.33	.53	.18	.35	.51
		1500	.01	.03	.10	.05	.11	.25	.07	.17	.38	.09	.20	.46	.09	.22	.49
	45°	500	.06	.13	.28	.18	.37	.71	.27	.50	.71	.30	.50	.67	.29	.47	.62
		1000	.02	.06	.13	.06	.14	.31	.11	.24	.51	.13	.29	.60	.15	.32	.63
		1500	–	.02	.08	.03	.09	.20	.06	.14	.31	.07	.17	.38	.08	.19	.42
	30°	500	.04	.09	.39	.13	.29	.73	.20	.41	.69	.23	.44	.63	.24	.43	.57
		1000	.01	.04	.10	.05	.11	.26	.09	.19	.41	.10	.23	.51	.12	.26	.56
		1500	–	.01	.06	.02	.07	.14	.04	.11	.24	.06	.13	.29	.07	.15	.34

PROTECTION CATEGORY: A (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: 1 HOUR

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	VWH 500 NO. AIRCRAFT 1	500: 2	500: 4	VWH 750 NO. AIRCRAFT 1	750: 2	750: 4	VWH 1000 NO. AIRCRAFT 1	1000: 2	1000: 4	VWH 2000 NO. AIRCRAFT 1	2000: 2	2000: 4	VWH 3000 NO. AIRCRAFT 1	3000: 2	3000: 4
ONE TANK AT HALF FLOW	90°	500	.08	.20	.27	.25	.50	.70	.36	.57	.69	.33	.53	.64	.28	.48	.58
		1000	.02	.06	.15	.10	.22	.47	.16	.34	.65	.19	.39	.65	.22	.40	.63
		1500	–	.04	.09	–	.10	.23	–	.12	.34	–	.15	.41	–	.21	.42
	45°	500	.06	.14	.30	.19	.40	.71	.28	.52	.72	.31	.52	.68	.30	.49	.64
		1000	.02	.06	.14	.07	.15	.33	.11	.25	.52	.14	.29	.55	.16	.32	.54
		1500	–	.02	.07	–	.08	.19	–	.13	.34	–	.16	.38	–	.19	.43
	30°	500	.04	.10	.22	.14	.30	.63	.21	.43	.69	.24	.45	.65	.25	.45	.59
		1000	.01	.04	.10	.05	.12	.27	.09	.19	.41	.10	.23	.48	.12	25	.49
		1500	–	.01	.05	–	.06	.14	–	.11	.24	–	.14	.31	–	.16	.37
TWO TANKS AT HALF FLOW	90°	500	.11	.24	.41	.32	.57	.74	.39	.59	.72	.35	.55	.69	.29	.47	.66
		1000	.03	.08	.19	.13	.28	.58	.21	.43	.72	.27	.49	.71	.31	.51	68
		1500	.01	.05	.14	.07	.16	.37	.12	.26	.56	.16	.34	.66	.19	39	.67
	45°	500	.08	.17	.37	.23	.48	.75	.35	.57	.72	.35	.55	.68	.32	.51	.65
		1000	.03	.08	.17	.09	.20	.42	.16	.34	.67	.20	.42	.71	.24	.47	.71
		1500	.01	.03	.10	.05	.13	.28	.09	.20	.44	.12	.26	.55	.14	.30	60
	30°	500	.05	.13	.51	.17	.37	.74	.26	.50	.71	.28	.49	65	.28	.48	.64
		1000	.02	.05	.13	.07	.16	.34	.12	.26	.55	.16	.33	.67	.18	38	.69
		1500	–	.02	.07	.03	.10	.20	.07	.15	.35	.10	.19	.43	.10	23	.48

Table I-80. Spray Tank/VX Expected Fraction of Casualties

PROTECTION CATEGORY: **A** (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: **ULTIMATE**

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	VWH 500: 1	500: 2	500: 4	VWH 750: 1	750: 2	750: 4	VWH 1000: 1	1000: 2	1000: 4	VWH 2000: 1	2000: 2	2000: 4	VWH 3000: 1	3000: 2	3000: 4
ONE TANK AT HALF FLOW	90°	500	.14	.31	.43	.39	.62	.74	.39	.59	.69	.35	.55	.65	.30	.50	.60
		1000	.05	.12	.26	.18	.38	.69	.30	.54	.73	.35	.56	.70	.36	.56	.68
		1500	--	.06	.15	--	.21	.42	--	.31	.56	--	.34	.59	--	.41	.59
	45°	500	.10	.23	.49	.30	.56	.75	.39	.60	.72	.36	.56	.68	.33	.53	.65
		1000	.04	.10	.22	.12	.26	.53	.19	.39	.63	.23	.43	.61	.26	.44	.59
		1500	--	.06	.12	--	.16	.33	--	.27	.54	--	.35	.62	--	.41	.65
	30°	500	.07	.16	.36	.22	.45	.74	.30	.54	.69	.31	.52	.65	.30	.50	.60
		1000	.03	.07	.16	.09	.20	.42	.14	.29	.55	.16	.34	.56	.18	.35	.55
		1500	--	.04	.09	--	.12	.25	--	.20	.45	--	.27	.55	--	.33	.59
TWO TANKS AT HALF FLOW	90°	500	.18	.38	.64	.43	.64	.75	.39	.59	.73	.35	.55	.70	.30	.50	.67
		1000	.06	.15	.30	.21	.45	.74	.35	.59	.73	.39	.60	.71	.39	.59	.69
		1500	.04	.09	.22	.13	.28	.60	.22	.46	.72	.30	.54	.74	.34	.56	.72
	45°	500	.13	.28	.58	.35	.60	.75	.40	.61	.72	.36	.56	.68	.34	.53	.65
		1000	.05	.11	.27	.16	.33	.66	.27	.52	.75	.33	.57	.73	.37	.59	.72
		1500	.03	.06	.16	.10	.21	.44	.16	.34	.65	.21	.42	.69	.24	.46	.68
	30°	500	.09	.20	.72	.26	.51	.74	.33	.56	.74	.32	.53	.70	.31	.50	.67
		1000	.04	.09	.20	.12	.26	.54	.20	.41	.73	.25	.49	.74	.29	.53	.73
		1500	.02	.04	.12	.07	.16	.32	.12	.25	.52	.15	.30	.60	.17	.34	.61

Table I-81. Spray Tank/VX Expected Fraction of Casualties

(Column headers: WINDSPEED-HEIGHT PRODUCT (VWH) 500, 750, 1000, 2000, 3000; each with NO. AIRCRAFT 1, 2, 4.)

Section XI
HD Munitions

HD DOSAGE REQUIREMENTS

HD DOSAGES mg/minute/cubic meter			PERSONNEL PROTECTION CATEGORY	CASUALTY EFFECTS	DEGREE OF DISABILITY	ONSET TIME	DURATION
HOT[1]	WARM[2]	COOL[3]					
50	50	50	"A" no mask or protective clothing	No significant injury; maximum safe dosage	--	--	--
100	100	100		Eye damage of threshold military significance	PARTIAL	6-24 HR	1-3 DAYS
200	200	200		Temporary blindness	TOTAL	3-12 HR	2-7 DAYS
100	150	400	"B" or "C" with no protective clothing	No significant injury; maximum safe dosage	--	--	--
200	300	1,000		Skin burns of threshold military significance	PARTIAL	2-12 DAYS	1-2 WEEKS
500	1,000	2,000 to 4000		Severe genital burns	PARTIAL TO TOTAL	2-7 DAYS	1-4 WEEKS
750	2,000 to 4,000	4,000 to 10,000		Severe generalized burns	PARTIAL TO TOTAL	4-12 HRS About 24 HRS	3-4 WEEKS 1-2 WEEKS
			"D" mask with protective clothing	HD IS NOT RECOMMENDED FOR USE IN THIS PROTECTION CATEGORY.			

[1]Hot, humid; above 80°F; sweating skin
[2]Warm: 60°-80°F; skin not wet with sweat
[3]Cool: 40°-60°F; cool, dry skin

Table I-85. HD Munitions

HD Contamination Replenishment Time (Rate Factors)

TERRAIN FACTOR	X	WINDSPEED FACTOR	X	GROUND SURFACE TEMPERATURE FACTOR	X	TEMPERATURE GRADIENT FACTOR[2] (STABILITY)	=	TIME (HOURS) FOR 50% EVAPORATION OF HD

FACTORS

TERRAIN	WINDSPEED[1] (knots)	GROUND SURFACE TEMPERATURE (°F)	TEMPERATURE GRADIENT[2]
	1 = 3.1		
OPEN	2 = 1.8		INVERSION = 1.2
GRASSLAND = 1	3 = 1.3		
	4 = 1.0	50° = 4.0	
		60° = 2.5	
FOREST OR	5 = 0.8	70° = 1.6	NEUTRAL = 1.0
JUNGLE = 1	6 = 0.7	80° = 1.0	
	7 = 0.6	90° = 0.6	
	9 = 0.5	100° = 0.4	
	11 = 0.4	110° = 0.3	
		120° = 0.2	
BARREN SOIL	14 = 0.3		LAPSE = 0.7
OR SAND = 2	18 = 0.3		

[1]at 2 meters high in the open
[2]in the open

Table I-96. HD Contamination Replenishment Time (Rate Factors)

Approximate Duration of Hazard in Contaminated Terrain

TASK	TERRAIN	APPROXIMATE TIME AFTER CONTAMINATION THAT PRESCRIBED TASKS MAY BE PERFORMED WITH NEGLIGIBLE RISK[1] (Not wearing protective clothing)[2]			
		BLISTER AGENT (HD) TEMPERATURE[3]		NERVE AGENT (VX-GB) UNIFORM[4]	
		WARM (70°-85°F)	HOT (80°-100°F)	SUMMER	WINTER
		WEARING MASKS			
TRAVERSAL[5] (Walking across area 2 hours or less	Bare soil or low vegetation[6] (except sand)	36 HOURS	36 HOURS	5 HOURS	2 HOURS
	High vegetation, including jungle and heavy woods	4 DAYS	2 DAYS	28 HOURS	10 HOURS
		NOT WEARING MASKS[7]			
OCCUPATION (Without hitting ground 24 hours)	Bare soil or low vegetation[6] (except sand)	4 DAYS	3 DAYS	32 DAYS	13 DAYS
	High vegetation, including jungle and heavy woods	4 DAYS	3 DAYS	32 DAYS	13 DAYS
OCCUPATION (Involving advance under fire 24 hours)	Bare soil or low vegetation[6] (except sand)	4 DAYS	3 DAYS	32 DAYS	13 DAYS
	High vegetation including jungle and heavy woods	6 DAYS	4 DAYS	50 DAYS	18 DAYS

[1]These times are safe-sided for troop safety.
[2]Leather combat boots treated with protective dubbing or rubber combat boots are worn.
[3]Effects of blister agent vary significantly with temperature. Mustard freezes in temperatures below 60°F and can present a hazard when the temperature rises.
[4]Protection from V-agent and thickened G-agent varies significantly with layers of clothing worn.
[5]For personnel walking for 2 hours in an area contaminated by blister agents, the limiting factor is the vapor hazard. If only a few minutes are required for traversal of the area, the task can be initiated at earlier times than those given.
[6]Times shown are not applicable to sand, which will hold chemical agents for longer periods of time than those given.
[7]The data refer to approximate times at which personnel could occupy contaminated areas without having to wear protective masks for protection against vapor hazard.

Table I-97. Approximate Duration of Hazard in Contaminated Terrain

WARNING
This table is intended as a guide only.
Chemical agent detectors must be used to determine the extent of actual contamination and vapor hazards.

POTENTIAL MILITARY CHEMICAL/BIOLOGICAL AGENTS AND COMPOUNDS, US Army FM 3-11.9, 2005

Table G-4. Toxicity Estimates for CW Agents

ROE		Liquid (mg/70 kg man)	Inhalation/Ocular (mg-min/m^3)	Percutaneous Vapor (mg-min/m^3)	
				Lethal (LCt_{50})	
Endpoints		Lethal (LD_{50})	Lethal (LCt_{50})	Moderate	Hot
Choking Agents	CG	-	1,500 (2-60)	-	-
	DP	-	1,500P (10-60)	-	-
Nerve Agents	GA	1,500	70 (2)	15,000 (30-360)	7,500P (30-360)
	GB	1,700	35 (2)	12,000 (30-360)	6,000P (30-360)
	GD	350	35 (2)	3,000 (30-360)	1,500P (30-360)
	GF	350	35 (2)	3,000 (30-360)	1,500P (30-360)
	VX	5	15 (2-360)	150 (30-360)	75P (30-360)
	Vx	NR			
Blood Agent	AC	-	2860P (2)	-	-
	CK	-	NR	-	-
	SA	-	7,500P (2)	-	-
Blister Agents	HD	1400	1,000 (2)	10,000 (30-360)	5,000P (30-360)
	L	1400P	1,000P (2-360)	5,000 - 10,000P (30-360)	2,500 - 5,000P (30-360)
	HL	1400P	1,000P (2-360)	10,000P (30-360)	5,000P (30-360)

It may be several weeks or even months before I shall ask you to drench Germany with poison gas, and if we do it, let us do it one hundred per cent. In the meanwhile, I want the matter to be studied in cold blood by sensible people and not by that particular set of psalm-singing uninformed defeatists which one runs across now here, now there (Churchill 1944).

Gilbert M (1991). *Churchill. A Life*, pp. 782–783. London: Heinemann.

ADA488135

USAWC RESEARCH ELEMENT
(Research Paper)

What's Wrong With Gas Warfare?

by

Lt Col Stanley D. Fair
Chemical Corps

US Army War College
Carlisle Barracks, Pennsylvania
8 April 1966

PUBLIC INFORMATION PROGRAM

A new national policy on gas warfare such as the one presented above can provide the necessary guidance for the people as to the importance of gas weapons and their role. The formulation of policy must precede or accompany any attempt to educate the public on gas warfare since "public knowledge of facts is not understanding until it can be set in the framework of policy and goals."[11]

Public resistance to a new policy may occur because of false impressions about gas warfare. Since the American people have considerable influence on adoption of policy, they must be provided objective information on gas warfare. As "Elihu Root...wrote... when policy on foreign affairs is largely dominated by the people, the danger lies in mistaken beliefs and emotions."[12]

The issue of gas warfare is emotional and political. In this respect it is similar to many issues facing our government today; communism and race relations are examples. Government officials have led the way with free and open discussions on these controversial subjects and should do the same with gas warfare. This leadership is essential, as Major General W.M. Creasy warned a House Science Committee in 1959:

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[11] "Public Understanding--The Ultimate Weapon?" The General Electric Defense Quarterly, Vol. 3, Oct.-Dec. 1960, p. 33.

[12] William Albig, Modern Public Opinion, p. 12.

Albig, William. Modern Public Opinion. New York: McGraw-Hill, 1956. (HM261 A451)

> I do not believe the American people are going to read any information on a subject when the American government says this is too horrible to use and we are not going to use it.[13]

The first step in a public information program is to go after the roots of public hostility towards gas warfare: World War I propaganda. The effects of the Allied propaganda did not evaporate with the gas clouds of World War I "for that half-century-old vision of the blue-faced men at Ypres choking to death, has left an indelible impression upon the mind of the world."[14] As late as 1953 the horrors of the first gas attack were brought out in the memoirs of a war correspondent who served with the Red Cross at Ypres:

> This horror was too monstrous to believe at first... the savagery of it, of the sight of men choking to death with yellow froth, lying on the floor and out in the fields, made me rage with an anger which no later cruelty of man...ever quite rekindled; for then we still thought all men were human.[15]

The tragedy of the first gas attack should be admitted in any program of public information: the soldiers were helpless; those who did not panic and run suffered a slow and painful death. On the other hand, it should be pointed out that protection against chlorine was simple and was achieved before the second gas attack took place two days later. Ypres was an isolated incident.

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[13] Quoted in US Congress, House, Committee on Science and Astronautics, Chemical, Biological and Radiological Warfare Agents, p. 22.

[14] Hanson W. Baldwin, "After Fifty Years the Cry of Ypres Still Echoes--'GAS!'," New York Times Magazine, 18 Apr. 1965, p. 50.

[15] Geoffrey W. Young, The Grace of Forgetting, p. 233.

The best counter to propaganda is to tell the truth. In getting the facts to the public it is important to differentiate between information which can and cannot be made available to the public. They should know in general what is going on, but the details must remain classified to protect national security. It is important also to differentiate between information which should and should not be made available to the public. Articles on gas warfare should pass the test of one criterion before release by the Department of Defense: does it contribute to public understanding of gas warfare, or does it add to the misconceptions of mystery and indecency?

The free and open discussion on nuclear warfare has resulted in the willingness of the responsible American to accept the nuclear weapon as an unpleasant fact, essential to his country's safety. The current secrecy surrounding gas warfare can create a lack of confidence in the capabilities of gas. Captain Liddell Hart told of British tanks developed during World War II that were fitted with special searchlights for blinding the enemy as well as for night firing. This invention was "kept so secret that the commanders in the field regarded them distrustfully and thus repeatedly hesitated to employ such unfamiliar instruments."[19]

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[19] B.H. Liddell Hart, Deterrent of Defense, pp. 86-87.

CIVIL DEFENCE

why we need it

Message from the Home Secretary and the Secretary of State for Scotland

For over 30 years our country, with our allies, has sought to avoid war by deterring potential aggressors. Some disagree as to the means we should use. But whatever view we take, we should surely all recognise the need – and indeed the duty – to protect our civil population if an attack were to be made upon us; and therefore to prepare accordingly.

The Government is determined that United Kingdom civil defence shall go ahead. The function of civil defence is not to encourage war, or to put an acceptable face on it. It is to adapt ourselves to the reality that we at present must live with, and to prepare ourselves so that we could alleviate the suffering which war would cause if it came.

Even the strongest supporter of unilateral disarmament can consistently give equal support to civil defence, since its purpose and effect are essentially humane.

George Younger.

Why bother with civil defence?

Why bother with wearing a seat belt in a car? Because a seat belt is reckoned to lessen the chance of serious injury in a crash. The same applies to civil defence in peacetime.

War would be horrific. Everyone knows the kind of devastation and suffering it could cause. But while war is a possibility – however slight – it is right to take measures to help the victims of an attack, whether nuclear or 'conventional'.

But isn't it a waste of money in these days of nuclear weapons and the dreadful prospects of destruction?

No. It is money well spent if it shows people how they can safeguard themselves and their families.

But surely there is no real protection against a nuclear attack?

Millions of lives could be saved, by safeguards against radiation especially. But civil defence is not just protection against a nuclear attack. It is protection against *any* sort of attack. NATO experts reckon that any war involving the UK is likely at least to start with non-nuclear weapons. Indeed, while no war is likely so long as we maintain a credible deterrent, the likelihood of a nuclear war is less than that of a 'conventional' one.

But doesn't civil defence get people more war-minded, thus increasing the risk of conflict?

That is like saying people who wear seat belts are expecting to have more crashes than those who do not. Taking civil defence seriously means seeking to save lives in the catastrophe of an attack on our country.

To Sum Up

The case for civil defence stands regardless of whether a nuclear deterrent is necessary or not. Radioactive fallout is no respecter of neutrality. Even if the UK were not itself at war, we would be as powerless to prevent fallout from a nuclear explosion crossing the sea as was King Canute to stop the tide. This is why countries with a long tradition of neutrality (such as Switzerland and Sweden) are foremost in their civil defence precautions.

Civil defence is common sense

Further information:

Nuclear Weapons
ISBN 0 11 34055 X HMSO £3.50 (net)

Protect and Survive
ISBN 0 11 3407289 HMSO 50p (net)

Domestic Nuclear Shelters
ISBN 0 11 3407378 HMSO 50p (net)

Domestic Nuclear Shelters – Technical Guidance
ISBN 0 11 34073786 HMSO £5.50 (net)

CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

HEARINGS

BEFORE THE

JOINT COMMITTEE ON DEFENSE PRODUCTION CONGRESS OF THE UNITED STATES

NINETY-FOURTH CONGRESS

SECOND SESSION

APRIL 28, 1976

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74-307 WASHINGTON : 1976

STATEMENT OF HON. PAUL NITZE, FORMER SECRETARY OF THE NAVY, DEPUTY SECRETARY OF DEFENSE, AND MEMBER OF THE SALT DELEGATION

Mr. NITZE. Mr. Chairman, my interest in the questions which this committee is discussing began in 1944 when I was asked to be a director of the U.S. Strategic Bombing Survey. The required qualification of the directors was that they have no prior knowledge of military strategy or of air power, and could thus be presumed to be unbiased in appraising the effects of the immense U.S. strategic air effort in World War II. I spent the next 2 years in Europe and then in the Pacific in intensive work, in association with what I believe to have been the best talent available to this country, to try to understand something about both subjects. In the Pacific portion of the survey, as Vice Chairman, I was in effective command of the operation, including the detailed study of the effects of the weapons used at Hiroshima and Nagasaki.

Since that time much has changed. Weapons have increased in yield and missiles now have an intercontinental range. But these changes are hardly as revolutionary as the changes brought about by the role of effective air power in World War II and of the introduction of nuclear weapons in its closing phase. After all, the largest number of our nuclear reentry vehicles today are Poseidon warheads, each of which has an equivalent megatonnage less than twice that of the weapons used at Hiroshima and Nagasaki.

At Hiroshima and Nagasaki there was no air-raid warning and very few people availed themselves of the crude civil defense facilities which were available. Most of those that did, even at ground zero, in other words, directly under the explosion, which was at the optimum height of burst, survived. The trains were operating through Hiroshima 2 days after the explosion.

During the period 1944–1946, Mr. Nitze was Vice Chairman of the United States Strategic Bombing Survey. He was awarded the Medal of Merit by President Truman for service to the nation in this capacity.

STATEMENT OF HERMAN KAHN, DIRECTOR, HUDSON INSTITUTE

12

Probably an even better prototype for the situation we are thinking about is pre-World War II. After World War I, much of the world became sick of war, and war became "unthinkable" to most people, particularly in the victorious "Allied Powers." Strategists and publicists talked about poison gas and knock-out blows; they thought all the capital cities would be destroyed by poison gas in the first few days of a war. They did not understand the idea of limitations in warfare—of mutual deterrence even after hostilities have broken out.

We would argue that similar possibilities should be considered today. Nobody is interested in jumping into a nuclear war today. Nobody is going to want to execute the usual picture of nuclear war, in which each side presses every button and goes home. It is extraordinarily difficult to believe such a scenario.

13

Nevertheless, every scenario we write for nuclear war involves days, weeks or months of tension. Evacuation, last moment mobilizations are extraordinarily possible. By the way, evacuations occur not as a result of secret intelligence or in any attempt to try to outrun the missiles or the bombers. The *New York Times* and the *Washington Post* provide the warning perhaps days before the attack. People or governments then get frightened and decide to decrease their vulnerability to attack. The idea is, can you exploit such warning if it is printed in the papers?

21

TYPICAL STRATEGIC MOBILIZATION SCENARIOS

1. The "phony war," 1940 (5 months):
(a) Pre-crisis arms competition (UK, France, Germany and the U.S.S.R.).
(b) A major series of political-military crisis—
Militarization of the Rhineland (1936);
Anschluss (Austria) (1938);
Sudeten crisis (1938–39);
War in Poland (1939).
(c) De-escalation and negotiation (antagonists began a rapid buildup fearing a resumption of full scale conflict).
2. Korea (1950–53):
(a) Pre-war politico-military crises—
Soviet invasion of Iran (1946);
Soviet takeover of East European nations (1945–48);
Berlin blockade (1948);
Soviet intervention in Turkey and Greece;
Soviet military buildup, post WW-II.

143

STATEMENT OF E. P. WIGNER [1] FOR THE JOINT COMMITTEE ON DEFENSE PRODUCTION

[1] Dr. Wigner is a Nobel Laureate and an emeritus professor of physics at Princeton University and has long been associated with civil defense issues. He edited a 1968 study *Who Speaks for Civil Defense?*

145

THE ARGUMENTS AGAINST CIVIL DEFENSE

The argument which we heard after the U.S.S.R. civil defense efforts became generally apparent was that our installation of protection for our people would only induce the U.S.S.R. to augment its aggressive capability. We now know that such augmentation took place even though we did not organize a vigorous civil defense effort.

(Gross exaggerations, assuming Nevada desert type terrain with no thermal shadows by city skylines, no duck and cover, no clothing and fraudulent blast effects data which ignores Hiroshima's evidence)

APPENDIX III

U.S. CIVILIAN NUCLEAR FATALITY ESTIMATES[1] FOR VARIOUS COUNTERFORCE ATTACK SCENARIOS

Type of attack	Assumptions	Estimated fatalities
Comprehensive attack:		
Case 1, 60 percent destruction of military targets.	1 optimum height of burst and 1 surface burst warhead per each of 1,054 ICBM silos; pattern attack of SAC bases: unspecified attack on 2 SSBN support bases; good shelter posture.	3, 200, 000
Case 2, 60 percent destruction of military targets.	2 optimum height of burst warheads per each of 1,054 ICBM silos; no pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; poor shelter posture.	6, 700, 000
Case 3, 57–60 percent destruction of military targets.	2 surface burst warheads per each of 1,054 ICBM silos; pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; very poor shelter posture.	16, 300, 000
ICBM only attack:		
Case 1	2 550 kt optimum height of burst warheads per each of 1,054 ICBM silos.	[2] 4, 000, 000
Case 2, 42 percent silo destruction.	1 550 kt surface burst and 1 550 kt optimum height of burst warhead per each of 1,054 ICBM silos.	5, 600, 000
Case 3, 80 percent silo destruction.	1 3 Mt surface burst and 1 3 Mt optimum height of burst warhead per each of 1,054 ICBM silos.	18, 300, 000
Case 4	2 3 Mt surface burst warheads per each of 1,054 ICBM silos	[3] 20, 000, 000
Airlift attack:[4]		
Case 1	1 200 kt cruise missile warhead per each of 5 U.S. heavy airlift bases (Dover AFB, Del.; McGuire AFB, N.J.; Travis AFB, Calif.; Charleston AFB, S.C.; and McChord AFB, Wash.)	70, 000
Case 2	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases	210, 000
Case 3	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases uses offset targeting.	135, 000

[1] Department of Defense estimates as reported to the Senate Foreign Relations Committee, July 11, 1975, and published in "Analyses of Effects of Limited Nuclear War," pp. 12–24. Note that figures are fatalities only and not casualties and that attacks are restricted to military facilities (counterforce) rather than populated areas (countervalue). Shelter posture is a function of degree of hardening and the willingness of the population to use shelters.

[2] Under.

[3] Circa.

[4] Assumes allied victories in a European war supported by U.S. military airlift provide incentives for destruction of major American airlift centers.

Survival of the Relocated Population of the U.S. After a Nuclear Attack

FINAL REPORT • JUNE 1976 ORNL-5041

by

Carsten M. Haaland

Conrad V. Chester

Eugene P. Wigner

for

Defense Civil Preparedness Agency

Washington, D. C. 20301

OAK RIDGE NATIONAL LABORATORY

ADA026362

SURVIVAL OF THE RELOCATED POPULATION OF THE U.S. AFTER A NUCLEAR ATTACK

C. M. Haaland, C. V. Chester, and E. P. Wigner

ABSTRACT

The feasibility of continued survival after a hypothetical nuclear attack is evaluated for people relocated from high-risk areas during the crisis period before the attack. The attack consists of 6559 MT, of which 5951 MT are ground bursts, on military, industrial, and urban targets. Relocated people are assumed to be adequately protected from fallout radiation by shelters of various kinds. The major problems in the postattack situation will be the control of exposure to fallout radiation, and prevention of severe food shortages to several tens of millions of people. A reserve of several million additional dosimeters is recommended to provide control of radiation exposure. Written instructions should be provided with each on their use and the evaluation of the hazard. Adequate food reserve exists in the U.S. in the form of grain stocks, but a vigorous shipping program would have to be initiated within two or three weeks after the attack to avoid large scale starvation in some areas. If the attack occurred in June when crops on the average are the most vulnerable to fallout radiation, the crop yield could be reduced by about one-third to one-half, and the effects on crops of possible increased ultraviolet radiation resulting from ozone layer depletion by nuclear detonations may further increase the loss. About 80% of the U.S. crude refining capacity and nearly all oil pipelines would be either destroyed or inoperative during the first several weeks after an attack. However, a few billion gallons of diesel fuel and gasoline would survive in tank storage throughout the country, more than enough for trains and trucks to accomplish the grain shipments required for survival. Results of a computer program to minimize the ton-miles of shipments of grain between Business Economic Areas (BEAs) indicate that less than 2% of the 1970 rail shipping capacity, or less than 6% of the 1970 truck shipping capacity would be adequate to carry out the necessary grain shipments. The continuity of a strong federal government throughout the attack and postattack period is essential to coordinate the wide-scale interstate survival activities.

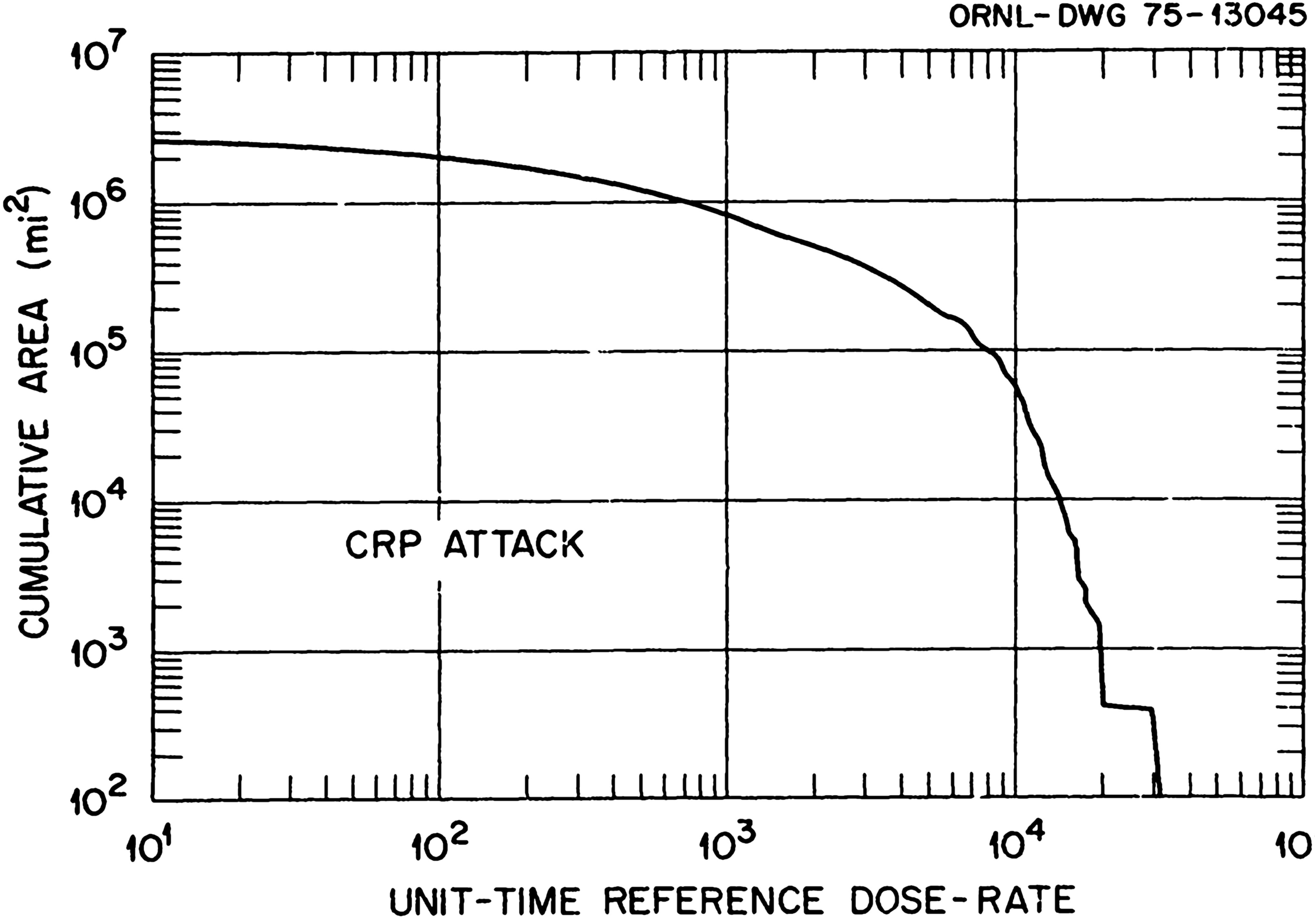

Fig. 4.2 Area of U.S. as a Function of Unit-Time Reference Dose Rate.

Environmental Radiation Protection Factors
Provided by Civilian Vehicles

Vehicle	Position	Protection Factor Range
Commercial bus (common type)	Throughout bus	1.5-2.0
Commercial bus (scenic cruiser type)	Throughout bus	1.5-2.0
School bus	Throughout bus	1.5-1.8
Passenger car	Passenger side (chest)	1.5-1.7
	Driver side	1.5-1.7
Pickup	Driver side	1.9-2.1
Crew cab	Driver side	1.8-2.0
	Back seat	1.8-2.0
Carryall	Driver side	1.7-1.9
	Rear side	1.7-1.9
2-1/2-ton truck	Driver side	1.8-2.0
	Center of bed	1.4-1.6
5-ton truck	Driver side	2.0-2.2
	Sleeper	1.9-2.1
Heavy Truck	Driver side	1.4-1.6
	Center of trailer	2.7-3.1
Fire truck	Driver side	2.7-3.1
	Standing area in back	1.6-1.8
Switch engine	Engineer's seat	3.0-3.5
Railway guard car	Sleeping quarters	2.2-2.6
	Kitchen area	2.4-2.8
	Center area	2.0-2.4
Heavy locomotive	Engineer's seat	3.0-3.5

SOURCE: Z. G. Burson, "Environmental and Fallout Gamma Radiation Protection Factors Provided by Civilian Vehicles," <u>Health Physics</u>, <u>26</u>, 41-44, 1974.

FOR EXTERNAL PUBLICATION

Radio Moscow in Mandarin to China, Nov. 3, 1978.

"However, the fact is that China's digging deep tunnels can never protect the Chinese masses from nuclear bombing or even protect them from conventional heavy bombs."

* * * * * * * * * *

Radio Moscow World Service in English, Nov. 16, 1978

"The U.S. Administration is going to launch a 5-year program of civil defense. - - - The only real safety for the Americans is strengthening friendship with the Soviet Union, not bomb shelters."

FOR INTERNAL PUBLICATION

Moscow *Voyennyye Znaniya* in Russian No. 5, May 1978, p. 33.

"It is appropriate to say that we still meet people who have an incorrect idea about defense possibilities. The significant increase in the devastating force of nuclear weapons compared with conventional means of attack makes some people feel that death is inevitable for all who are in the strike area. However, there is not and can never be a weapon from which there is no defense. With knowledge and the skillful use of contemporary procedures, each person can not only preserve his own life but can also actively work at his enterprise or institution. The only person who suffers is the one who neglects his civil defense studies."

~~TOP SECRET~~

A-381

DEPARTMENT OF DEFENSE

POLICY GUIDANCE FOR THE EMPLOYMENT OF NUCLEAR WEAPONS (NUWEP) (U)

OCTOBER 1980

22 DOD / DFOISR
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(24 Oct 80)

~~TOP SECRET~~

IV. STRATEGY FOR EMPLOYMENT

A. Flexibility

(U) The U.S. must have the capability to respond appropriately and effectively to any level of Soviet aggression, over the continuum of nuclear weapon employment options, ranging from use of a small number of strategic and/or theater nuclear capable weapon systems in a contingency operation, to a war employing all elements of our nuclear forces in attacks against a broad spectrum of enemy targets. The ability to respond with selectivity to less than an all-out Soviet attack in keeping with the needs of the situation is required in order to provide the National Command Authorities (NCA) with suitable alternatives, strengthen deterrence, and enhance the prospects of limiting escalation of the conflict. In addition to pre-planned options we need an ability to design employment plans on short notice in response to the latest and changing circumstances. To advance the goal of flexibility, planning will provide an objective-oriented series of building block options for the employment of nuclear weapons in ways that will enable us to employ them consonant with our objectives and the course of the conflict.

~~(C)~~ As it evolves, the building block approach should provide plans which satisfy a hierarchy of targeting objectives and which will provide the NCA an improved capability to employ nuclear weapons effectively in as measured and controlled a manner as feasible in case of a limited conflict. It should provide complementary elements which can be combined in an integrated and discrete manner to provide larger and more comprehensive plans for achieving politico-military objectives in specific situations. The building block approach places emphasis on the individual elements, their objective utility, and our ability to employ them separately or in total. However, this does not imply that the total plan be finely divisible--practical realities cannot be ignored. The desire for enhanced flexibility in employment must be balanced by practical consideration of the increased complexity incurred in planning and operations, the need to avoid compromising the effectiveness and workability of the larger options, and the need to maintain a responsive decisionmaking and force execution process.

RECOVERY FROM NUCLEAR ATTACK

by

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Work Unit 3539B
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December 1979

INTRODUCTION

On December 5, 1945, just 4 months after the news flash that an atomic bomb had been developed by the United States and had been dropped on Japan, Dr. Hans Bethe, Nobel prizewinner and one of the designers of the bomb, was called before the Special Committee on Atomic Energy of the U.S. Senate. The Committee was concerned that an atomic explosion might "ignite" the earth's atmosphere or start some sort of chain reaction in the air or in the ocean.

Dr. Bethe succeeded in reassuring the Committee that these and other "end-of-the-world" type effects are not to be expected. In general, such extreme fears no longer are taken seriously. However, other almost equally catastrophic visions have arisen to take their place. They include:

— the triggering of a new ice age, to be caused by the vast quantities of debris that would be thrown into the stratosphere and would serve to deflect the sun's rays away from earth. (Although we cannot rule out the possibility of some changes in climate if a very large scale nuclear exchange should occur, most of the particles would descend airly quickly and the changes in climate, even if noticeable, would be transitory.)

— upsetting the delicate balance of nature, leading to disastrous changes in the ecological systems. For example, it has been suggested that since birds are more sensitive than insects to gamma radiation, fallout could kill off the birds - the predators - leaving the insects - the prey - to multiply without control. (Study has shown that when other relevant factors are considered, this is not likely to occur. The insects would be subjected to much more beta radiation than the birds, and control mechanisms other than simple predator/prey relationships affect population control.)

— creation of vast radioactive wastelands that would be uninhabitable for generations. Some areas, especially near ground - zero of surface - burst weapons, would continue to be highly radioactive for many years. (Much of the country, however, would be scarcely affected at all and much of it initially interdicted because of fallout could be reclaimed by decontamination, or, within weeks or months, could be used after the natural radioactive decay had reduced the radiation levels to acceptable values.)

— great increases of leukemia and other malignancies among the survivors - due to exposures to fallout radiation. In the 50's and early 60's many people believed that survivors of a nuclear attack inevitably would die of bone cancer from Strontium-90, (Research has shown that Strontium-90 is not the hazard it was first thought to be. The basic reason is that most of the bomb-produced Strontium-90 is not "biologically available;" that is, it does not get into the food chain. Also, methods for decontaminating food have been developed if the need should ever arise. Some increase in the rate of malignancy among survivors of a nuclear attack would be expected, but in no sense would the increase threaten the survival of the society.)

— vast increases in congenital defects due to gene mutations caused by radiation, lasting for many generations. (Some radiation-induced genetic mutations would occur among the survivors of a nuclear war, but, as in the case of the malignancies, their impact would not be important in terms of the survival of the society.)

— depletion of the ozone layer in the stratosphere. This could decrease protection from ultraviolet radiation and cause proliferation of skin cancers, kill wild and domestic animals, and make it difficult, if not impossible, to grow many of the crops that provide our food and fiber. (This hypothesis is the latest and its validity is yet to be established one way or the other. If research confirms that ozone depletion resulting from the detonation of nuclear bombs is a serious potential hazard, research would be needed to evaluate the degree of the hazard and what could be done to reduce its effects.)

— breakdown of our highly sophisticated and complex social and economic systems due not only to loss of key facilities and personnel, but also because of functional disruption and behavioral breakdowns. (This hypothesis is less specific than those relating to the physical effects of nuclear weapons, and is much more difficult to formulate or investigate. It remains at this time one of the major "unknowns.")

An underlying basis for these negative hypotheses may be psychological. If everyone "knew" that nuclear war would mean the end of the human species, somehow the world would appear more secure since no sane person would initiate a series of events that would lead to everyone s death, including his own. In such a way does the idea of "assured destruction" contain elements of reassurance to some people.

The potential threats to recovery from nuclear war have received a significant amount of study. The Defense Civil Preparedness Agency (and its predecessors) in the decade from 1963 to 1973 allocated some $17 million to research in the general area of postattack recovery. The Federal Preparedness Agency (and its predecessors) have conducted both contract and in-house research at a cost of another several million dollars, with much of this FPA work focused almost exclusively on the problem of economic recovery.

Other agencies have also been involved. From the early days following World War II the former Atomic Energy Commission and its successors, now the Department of Energy, have sponsored elaborate research programs aimed at investigating the various possible deleterious consequences of exposure to ionizing radiation and developing means of protecting against them. This radiological research program has included a cooperative effort with the Japanese to study the longer-term effects of radiation exposure on the survivors of Hiroshima and Nagasaki and their offspring. This program continues today, and will for many years to come.

To date, approximately $1.5 billion has been allocated by the AEC and its successors for research associated with ionizing radiation and its effects. From these 30 years of scientific studies, much is known about the hazards of radiation — more than is known about many of the other hazards that man faces, probably including the common cold.

Robert Scheer

WITH ENOUGH SHOVELS: Reagan, Bush & Nuclear War

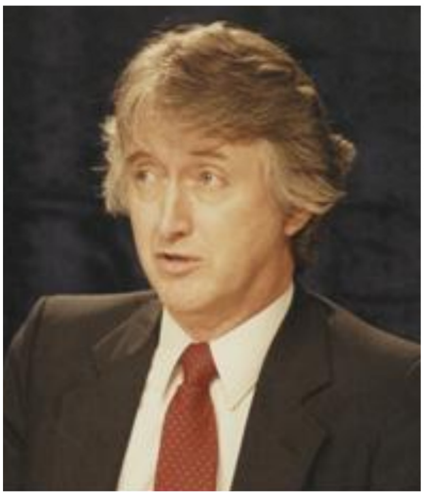
"Dig a hole, cover it with a couple of doors and then throw three feet of dirt on top... It's the dirt that does it... if there are enough shovels to go around, everybody's going to make it."

—T. K. Jones, Deputy Under Secretary of Defense for Strategic and Theater Nuclear Forces

"President Ronald Reagan had been in office less than a year when he approved a secret plan for the United States to prevail in a protracted nuclear war. This secret plan, outlined in a so-called National Security Decision Document, committed the United States for the first time to the idea that a global nuclear war can be won."

With these words Robert Scheer, the distinguished national reporter for the *Los Angeles Times*, begins this astonishing revelation of how a handful of Cold War ideologues—led by the President himself—have reversed the longstanding American assumption that nuclear war means mutual suicide.

Scheer reveals that President Reagan finds it "ridiculous" to assume that nuclear war means mutual destruction.

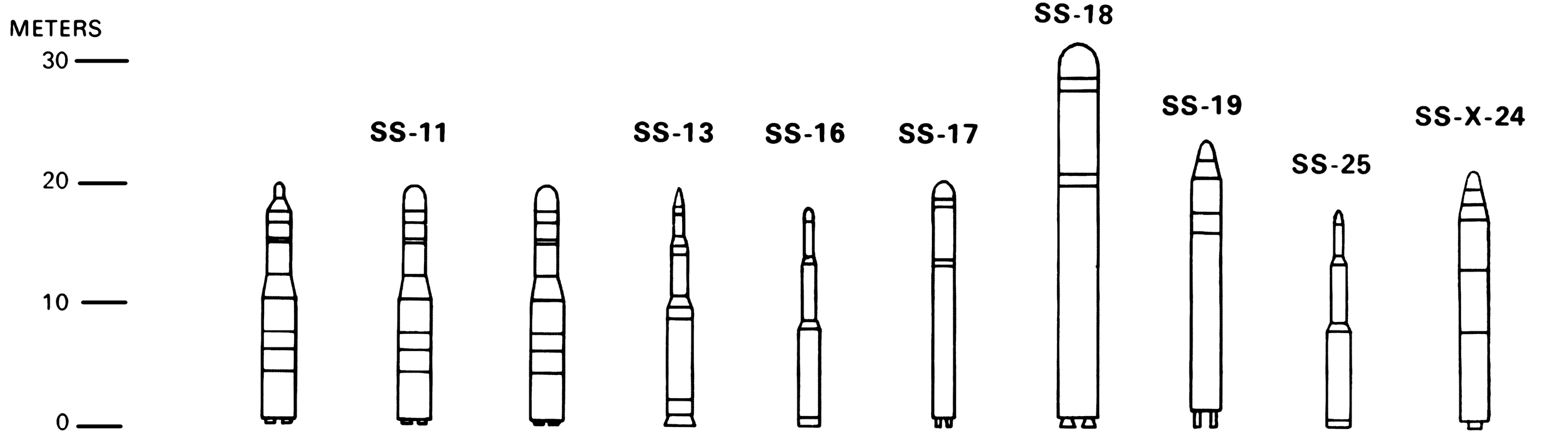


Thomas K. Jones, Ronald Reagan's Under Secretary of Defense: "Dig a hole ... throw 3 ft of earth on top ... everybody's going to make it." Shelters survived at Hiroshima (above right).

SOVIET MILITARY POWER

1986

USSR ICBMs



	SS-11 MOD 1	SS-11 MOD 2	SS-11 MOD 3	SS-13 MOD 2	SS-16	SS-17 MOD 3	SS-18 MOD 4	SS-19 MOD 3	SS-25	SS-X-24
NUMBER DEPLOYED	28	420		60	Undetermined	150	308	360	70+	In Development/ Testing
WARHEADS	1	1	3 MRVs	1	1	4 MIRVs	10+ MIRVs	6 MIRVs	1	Up to 10 MIRVs
MAX RANGE (KM)	11,000	13,000	10,600	9,400	9,000	10,000	11,000	10,000	10,500	10,000
LAUNCH MODE	Hot	Hot	Hot	Hot	Cold	Cold	Cold	Hot	Cold	Cold

US ICBMs

	TITAN II	MINUTEMAN II	MINUTEMAN III	PEACEKEEPER
NUMBER DEPLOYED	17*	450	550	In Development
WARHEADS	1	1	3	Up to 10
MAX RANGE (KM)	12,000	12,500	11,000+	11,000+
LAUNCH MODE	Hot	Hot	Hot	Cold

* As of early 1986

Gorbachev's Economic Program: Problems Emerge

DDB-1900-187-88
June 1988

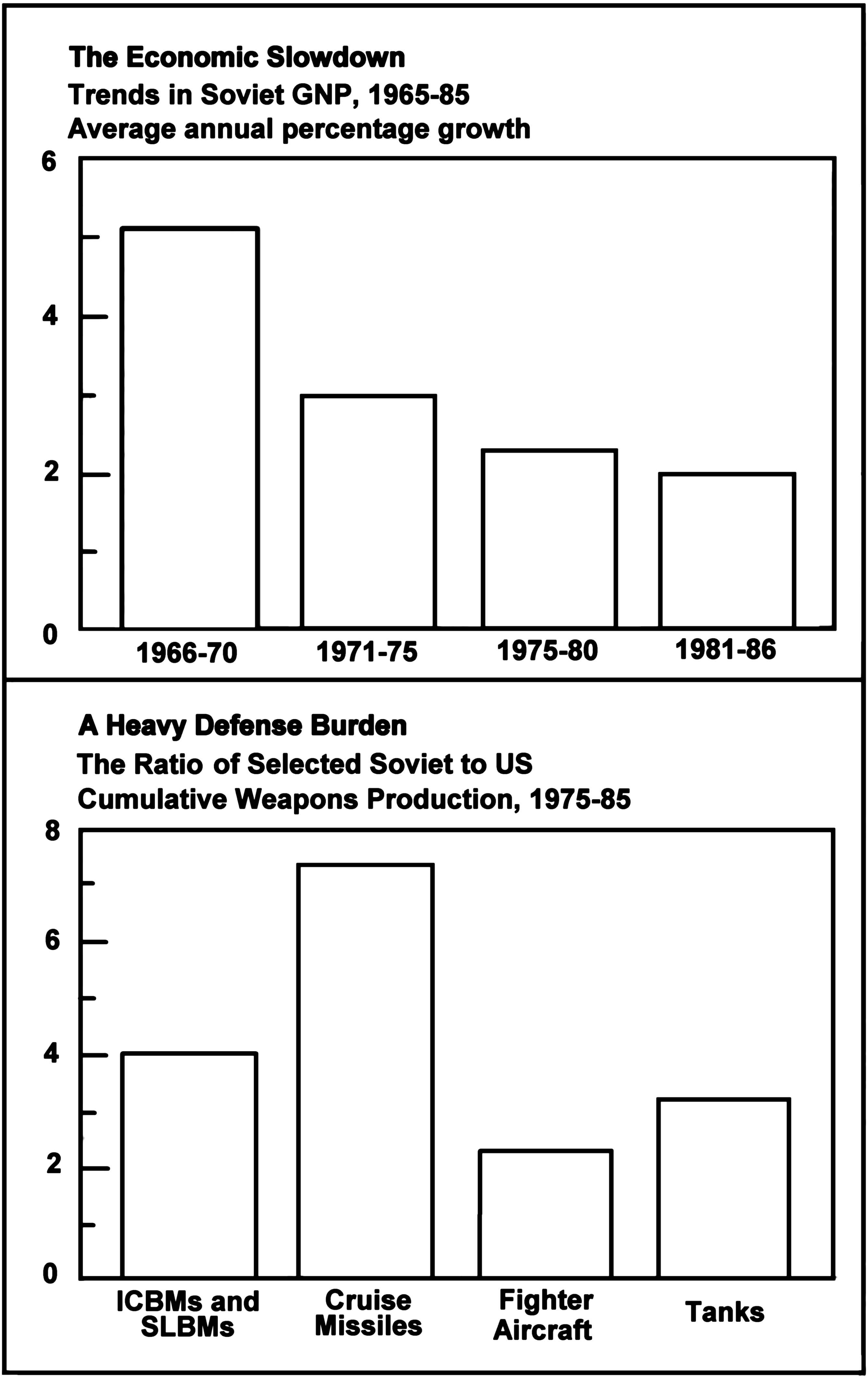


Figure 1. Gorbachev's Domestic Imperative

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THE WHITE HOUSE

WASHINGTON

91001

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January 17, 1983

Declassified/Released 7/16/94 under provisions of E.O. 12356 by D. Van Tassel, National Security Council F94-1102

National Security Decision Directive Number 75

U.S. RELATIONS WITH THE USSR (S)

U.S. policy toward the Soviet Union will consist of three elements: external resistance to Soviet imperialism; internal pressure on the USSR to weaken the sources of Soviet imperialism; and negotiations to eliminate, on the basis of strict reciprocity, outstanding disagreements. Specifically, U.S. tasks are:

1. To contain and over time reverse Soviet expansionism by competing effectively on a sustained basis with the Soviet Union in all international arenas -- particularly in the overall military balance and in geographical regions of priority concern to the United States. This will remain the primary focus of U.S. policy toward the USSR.

2. To promote, within the narrow limits available to us, the process of change in the Soviet Union toward a more pluralistic political and economic system in which the power of the privileged ruling elite is gradually reduced. The U.S. recognizes that Soviet aggressiveness has deep roots in the internal system, and that relations with the USSR should therefore take into account whether or not they help to strengthen this system and its capacity to engage in aggression.

3. To engage the Soviet Union in negotiations to attempt to reach agreements which protect and enhance U.S. interests and which are consistent with the principle of strict reciprocity and mutual interest. This is important when the Soviet Union is in the midst of a process of political succession. (S)

In order to implement this threefold strategy, the U.S. must convey clearly to Moscow that unacceptable behavior will incur costs that would outweigh any gains. At the same time, the U.S. must make clear to the Soviets that genuine restraint in their behavior would create the possibility of an East-West relationship that might bring important benefits for the Soviet Union. It is particularly important that this message be conveyed clearly during the succession period, since this may be a particularly opportune time for external forces to affect the policies of Brezhnev's successors. (S)

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3. Political Action: U.S. policy must have an ideological thrust which clearly affirms the superiority of U.S. and Western values of individual dignity and freedom, a free press, free trade unions, free enterprise, and political democracy over the repressive features of Soviet Communism. We need to review and significantly strengthen U.S. instruments of political action including: (a) The President's London initiative to support democratic forces; (b) USG efforts to highlight Soviet human rights violations; and (c) U.S. radio broadcasting policy. The U.S. should:

-- Expose at all available fora the double standards employed by the Soviet Union in dealing with difficulties within its own domain and the outside ("capitalist") world (e.g., treatment of labor, policies toward ethnic minorities, use of chemical weapons, etc.).

-- Prevent the Soviet propaganda machine from seizing the semantic high-ground in the battle of ideas through the appropriation of such terms as "peace." (S)

B. Geopolitical

1. The Industrial Democracies: An effective response to the Soviet challenge requires close partnership among the industrial democracies, including stronger and more effective collective defense arrangements. The U.S. must provide strong leadership

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LA-14066-H
History

Tracing the Origins of the W76: 1966–Spring 1973 (U)

Betty L. Perkins

November 3, 2003

Redacted Version

~~NUCLEAR WEAPON DATA~~
~~Sigma 1~~
~~Critical Nuclear Weapon Design Information~~
~~DoD Directive 5210.2 Applies~~

~~RESTRICTED DATA~~
~~This document contains Restricted Data as defined in the Atomic Energy Act of 1954. Unauthorized disclosure subject to administrative and criminal sanctions.~~

Classifier: Michael Pankratz
Derived from: LA-4000, Rev. 8, 9/02
July 14, 2003

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NATIONAL LABORATORY
Los Alamos NM 87545

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7. Yield: The Confetti Argument

Agnew felt that the yield of the W68 was too low to be really effective. In addition, in terms of the overall total yield available from all the W68 warheads, the W68 design was very costly in terms of the amount of required special nuclear materials.

In an April 1972 TWX to Assistant Director for Safety and Liaison (Division of Military Application) Colonel Robert T. Duff, Agnew reported that he was worried about maintaining the U.S. nuclear deterrent. Agnew noted, "It occurs to me that as we go to lower and lower yields in our strategic missile warheads and the Soviet Union builds up a better and better civil defense position, the reality of this deterrent may become questionable.

(b)(3)

If the Soviet leadership believes this, then our strategic deterrent will have lost a good deal of its force. If our MIRV trend continues we'll be threatening to throw confetti at a potential aggressor. Confetti has high penetration and survivability but little deterrent power."[281]

In a letter dated October 10, 1972, to Giller, at that time Assistant General Manager for National Security, Agnew again noted several reasons why low yield warheads might not be the best solution for maximizing the deterrence capability of the stockpile. He reported that considering the number of required submarines and the low efficiency in their use of special nuclear material, the low-yield warheads were not very cost effective. Moreover, Agnew pointed out that for the Hiroshima device, the effects on Hiroshima in terms of loss of substantial buildings and the people in them "wasn't all that impressive." In terms of loss of life, the USSR had lost more than ten million people in WWII. Although the Soviets had an extensive civil-defense network in place, even if that did not work to reduce loss of civilian lives, the Soviets might not mind losing a few people. Agnew wrote, "Again, to me, to continue to increase warhead numbers at the cost of a decrease in yield per warhead could eventually lead to no deterrence in the minds of those we hope to deter." Agnew stated, "I feel very strongly that we should endeavor to convince the DoD that what they should have on the next round is a mix of yields.

(b)(3)

8. Capability

Agnew in his August 10, 1972, letter to Camm pointed out that the Los Alamos group had been developing suitable technology applicable to the new strategic missile warheads. He wrote, "In summary then, we have been working very hard to provide the very latest technology in warhead designs incorporating the most advanced minimum weight hardening techniques to provide an optimum warhead for the next round of strategic missile warheads. In fact, our work has been of such outstanding quality that we have been invited by Admiral Levering Smith to

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[281]H. M. Agnew, University of California, Los Alamos Scientific Laboratory, Los Alamos, N.M. to BY3/Colonel Robert T. Duff, USAF, Assistant Director for Safety and Liaison, Division of Military Application USAEC, Wash., D.C. (SRD) (April 14, 1972), pp. 1–2, B11, Drawer 56, Folder 1 of 4.

(b)(3)

3. Reservoir Designs to Provide Minimum Helium in the Boost Gas

In a March 1969 memo, primary designer R. Canada outlined the problems that were the result of the formation of ^{3}He from the decay of the tritium used in the primary's boost gas.

(b)(3)

The yield of a boosted primary is degraded as tritium is converted to ^{3}He both by the loss of the source of 14-MeV neutrons and also by the decrease of the pre-boost multiplication rate caused by the high cross-section for neutron capture which is characteristic of ^{3}He." He went on to add, "In a conventional boosted single-stage device the tritium produced by ^{3}He appears too late in the bomb's explosion to contribute to the yield, and the temperature does not get high enough to produce significant ^{3}He + D fusion."[293]

(b)(3)

[293] R. Canada to Distribution, Subject: "^{3}He in Weapons," W-4-2518 (SRD) (March 10, 1969), 5 pp., A99-019, *199-13.*

(b)(3)